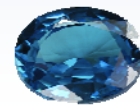# Using expert elicitation in the TOPAZ Project

COST Workshop, Rome
Ellie Scourse
MCM International, Bristol, UK
9th October 2014

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# Overview

- Radioactive waste and geological disposal
- Topaz project background and methodology
- Use of structured expert elicitation in the project
- Outputs from Topaz – integrated hazard maps

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# Radioactive Waste

- Waste from NPP, research and military operations.
- Treated and packaged to make as inert as possible.
- Options for long-term management of wastes:
  - Store indefinitely?
  - Deep Borehole Disposal?
  - Geological Disposal?

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# Overview of a Geological Repository

A passively safe system that prevents any releases reaching people and the environment in harmful concentrations

**The rock**
ISOLATES radioactivity from people by deep burial in rock

typically, 300 - 700 m

**Engineered Barriers** help to CONTAIN radioactivity for many thousands of years until 99.9% has decayed

**The rock** provides a stable 'geological cocoon' for the engineered containment system for hundreds of thousands of years
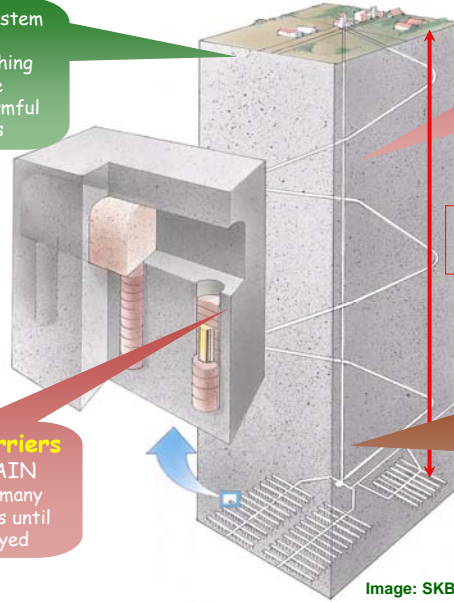
**Image: SKB, Sweden**

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# Forecasting Hazards to a High-Level Radioactive Waste Repository: what future timescales are critical?

| 1000 years | High hazard potential: the most important period for protection and safety |
|---|---|
| 10,000 years | Elevated but natural hazard levels: important, but not critical |
| 100,000 years | Low natural hazard level: we need to know about behaviour, but not important for safety |
| 1 million years | No significant safety concern |

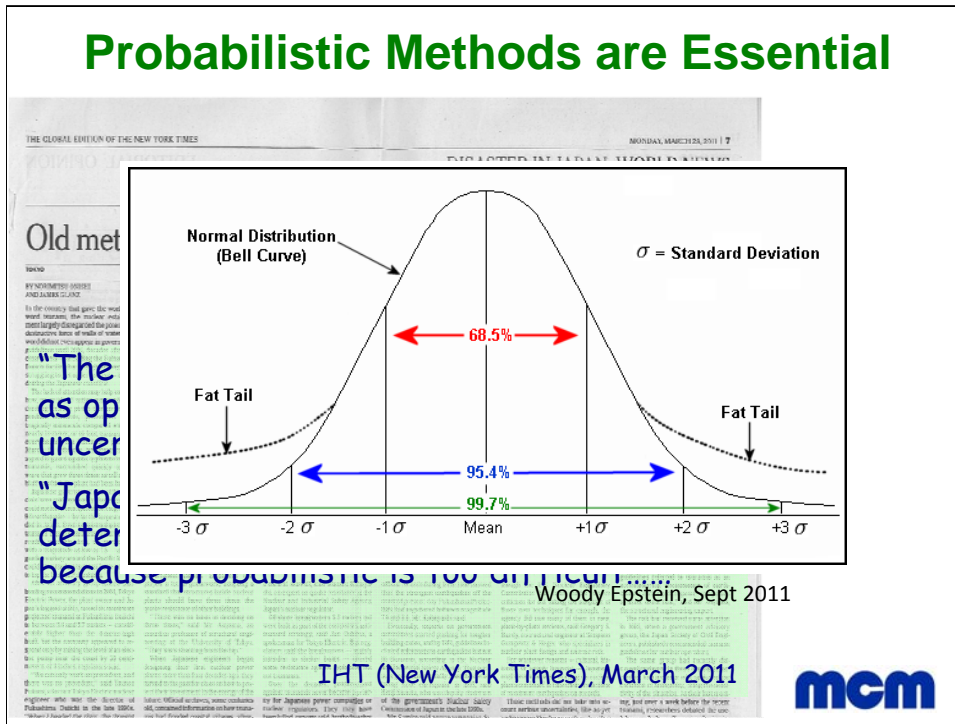The ITM-Topaz Methodology covers all of these timescales

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# The Story of ITM-Topaz

- We began in 2005 by looking at the geoscientific evidence and considering the question: *"Can a stable site for a repository be found in Japan?"*
    - Yes
- We then began to develop a methodology for finding such a tectonically stable site.

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Probabilistic Methods are Essential

Woody Epstein – his take on Fuk. And prob. things….read this as background. Use this slide as a marker for an introduction.

Point is – det. Evaluation tended to look at maximum things that seen in past, rather than looking at processes that cause it and assessing prob distribution dunctons and their TAILS –same for volcanoes, earthquakes, tsuanmas etc. Topaz is looking at full prob distribution not just tails but we're using prob appraoches, which is unusual in Japan – have had some resistance. But was picked up after Tohoku earthquake for toher reasons.

Overarching –use this for all eng. Design work, relutcatknt to look at prob appraocahes as think it's 'gambling' or 'guessing' – they think deterministic is the real answer.
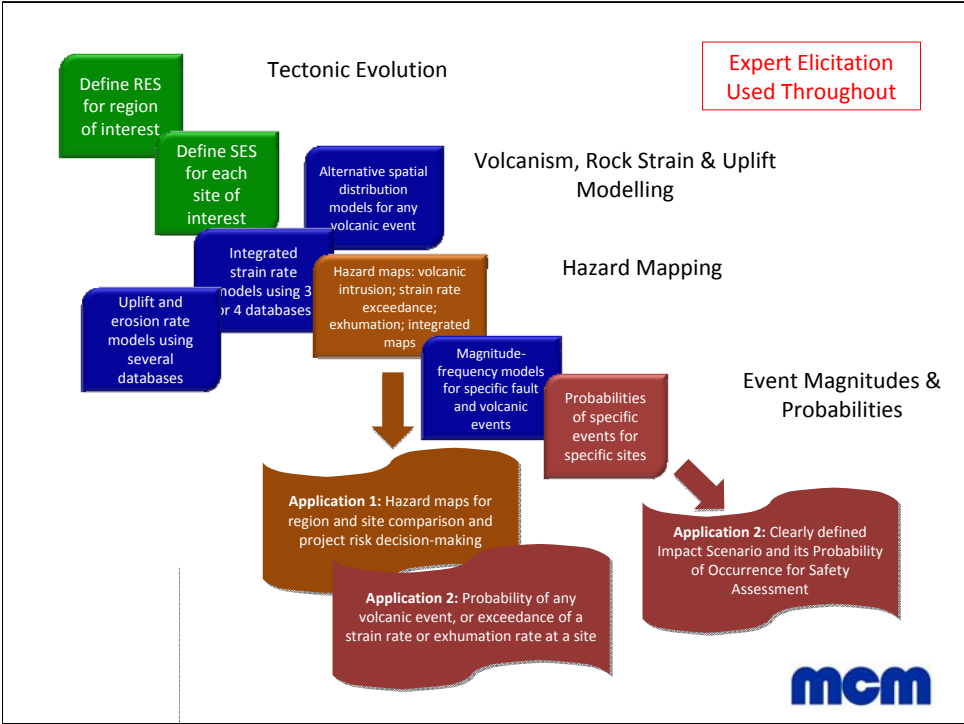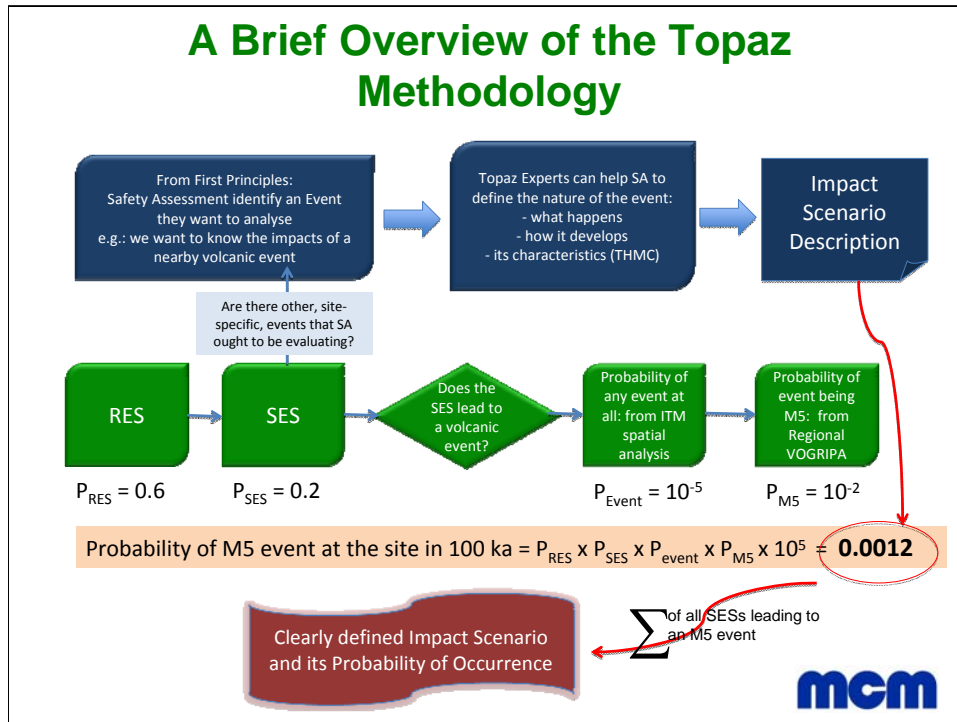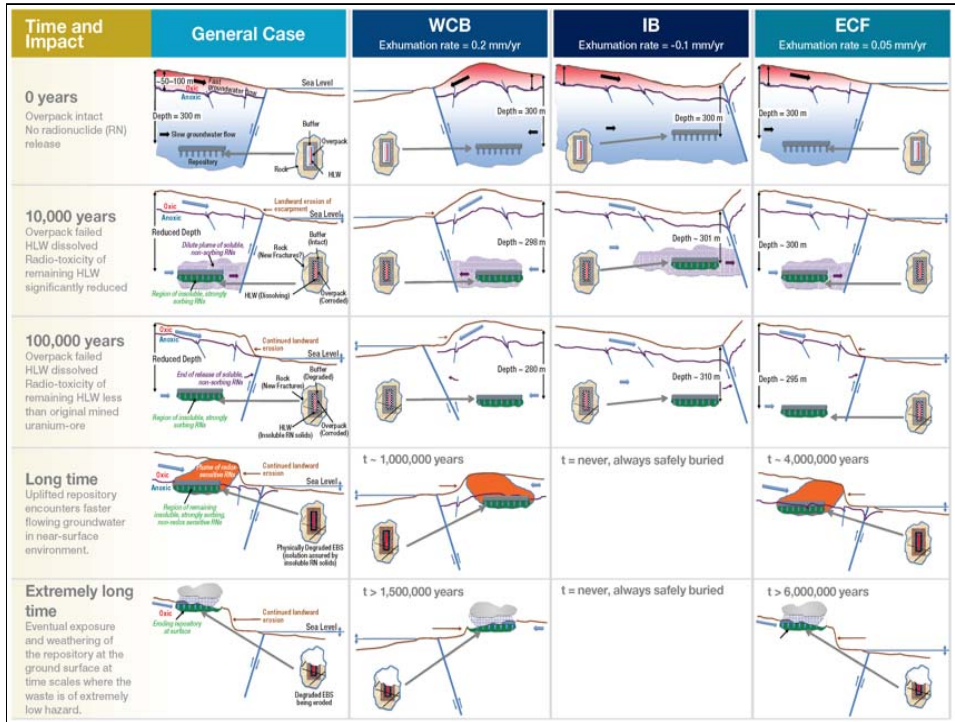
- EE? Put in a logic tree – explain that use these to get to prob values

# Impact Scenarios

- Impact Scenarios – hazard maps do not show the likelihood of events of specific magnitudes, so need to be interpreted if the probability of events is required.
  - An explosive event of > VEI 6
  - Strain release producing a single earthquake event of > Mw 6.5 on a concealed active fault
  - Exhumation (uplift – erosion) of 0.1mm/year
- These considered thresholds above which there would be significant impacts on a geological disposal facility.

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| Time and Impact | General Case | WCB Exhumation rate = 0.2 mm/yr | IB Exhumation rate = -0.1 mm/yr | ECF Exhumation rate = 0.05 mm/yr |
|---|---|---|---|---|
| **0 years** Overpack intact No radionuclide (RN) release | Depth = 300 m | Depth = 300 m | Depth = 300 m | Depth = 300 m |
| **10,000 years** Overpack failed HLW dissolved Radio-toxicity of remaining HLW significantly reduced | Reduced Depth | Depth ~ 298 m | Depth ~ 301 m | Depth = 300 m |
| **100,000 years** Overpack failed HLW dissolved Radio-toxicity of remaining HLW less than original mined uranium-ore | Reduced Depth | Depth ~ 280 m | Depth ~ 310 m | Depth ~ 295 m |
| **Long time** Uplifted repository encounters faster flowing groundwater in near-surface environment. | | t ~ 1,000,000 years | t = never, always safely buried | t ~ 4,000,000 years |
| **Extremely long time** Eventual exposure and weathering of the repository at the ground surface at time scales where the waste is of extremely low hazard. | | t > 1,500,000 years | t = never, always safely buried | t > 6,000,000 years |

# Overview of Logic Trees

- Graphical representation of a series of events – branches are logical steps from a previous event through increasingly specific subsequent events.
- 3 TOPAZ logic trees: volcanism, rock deformation and exhumation.

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Current magmatic system — Extinct? — Recurrence rate model — Spatial density model
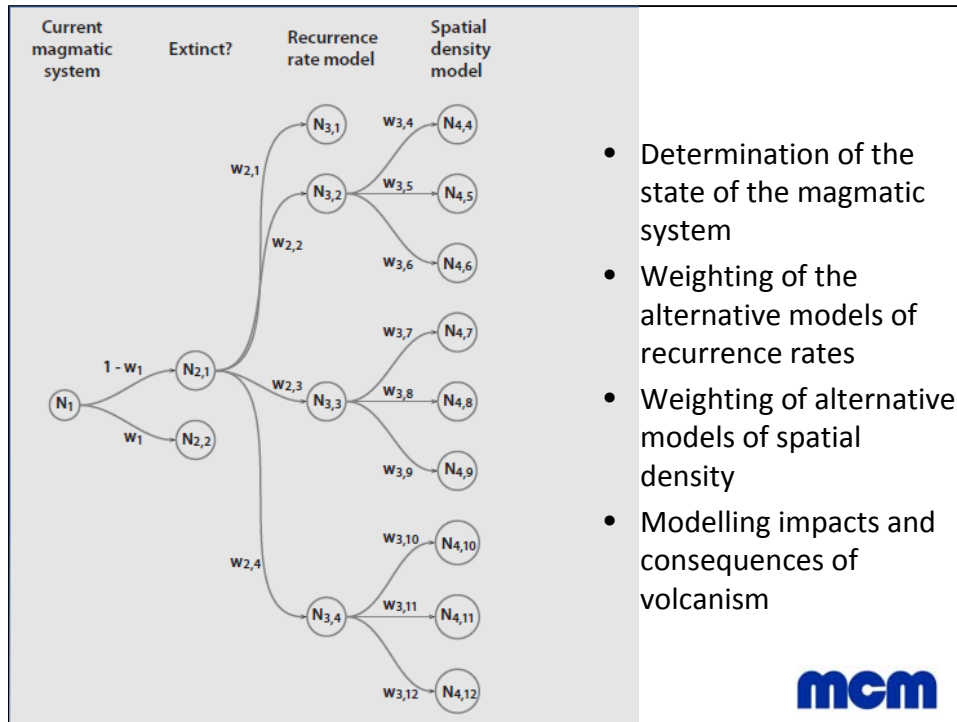
- Determination of the state of the magmatic system
- Weighting of the alternative models of recurrence rates
- Weighting of alternative models of spatial density
- Modelling impacts and consequences of volcanism

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# Using Experts in an EE exercise – ITM-Topaz

- Expert Elicitation is a formal, quantitative process for combining opinions, which is transparent and fair.
- A workshop was held in October 2011 to show how expert elicitation works and to elicit some nodes of the logic trees.
- 21 experts were 'weighted' using seed questions to analyse their ability to assess uncertainty.
- A report was produced outlining the results – 'Report on the TOPAZ Structured Expert Elicitation Demonstration Workshop' November 2011.
- **Demonstration exercise so far.**
- Full elicitation of whole logic trees would require more data, be intensive and take several days of commitment by experts.

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# Process for implementing the EE exercise in Topaz (1)

- 1. Select an informed team of experts
  - for this project, experts from NUMO plus domestic Japanese experts and members of the international Topaz team

- 2. 'Seed' questions asked of each expert within their specific fields of expertise
  - calibrate each expert for statistical accuracy and informativeness

- 3. Provide experts with the scientific data and ask the questions related to the actual problem based logic trees

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# Process for implementing the EE exercise in Topaz (2)

- 4. Weight the outputs of each expert and combine
  - 'synthetic expert'
- 5. Produces a performance-based, group result as an uncertainty distribution that is open to analysis. Group result more credible than individual opinion.
- 6. Document outputs in report.


- Experts who might normally not want to be involved can find this transparent and objective approach attractive
- Requires an impartial and skilled facilitator

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# EE – Example Question
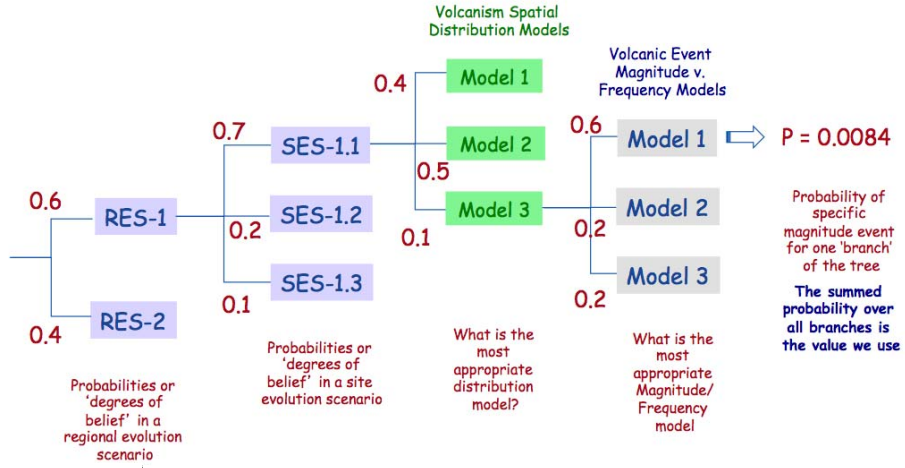
The responses were analysed and pooled with calibration weights to form a trio of quantile values representing collective judgement, for use on the relevant node of the logic tree

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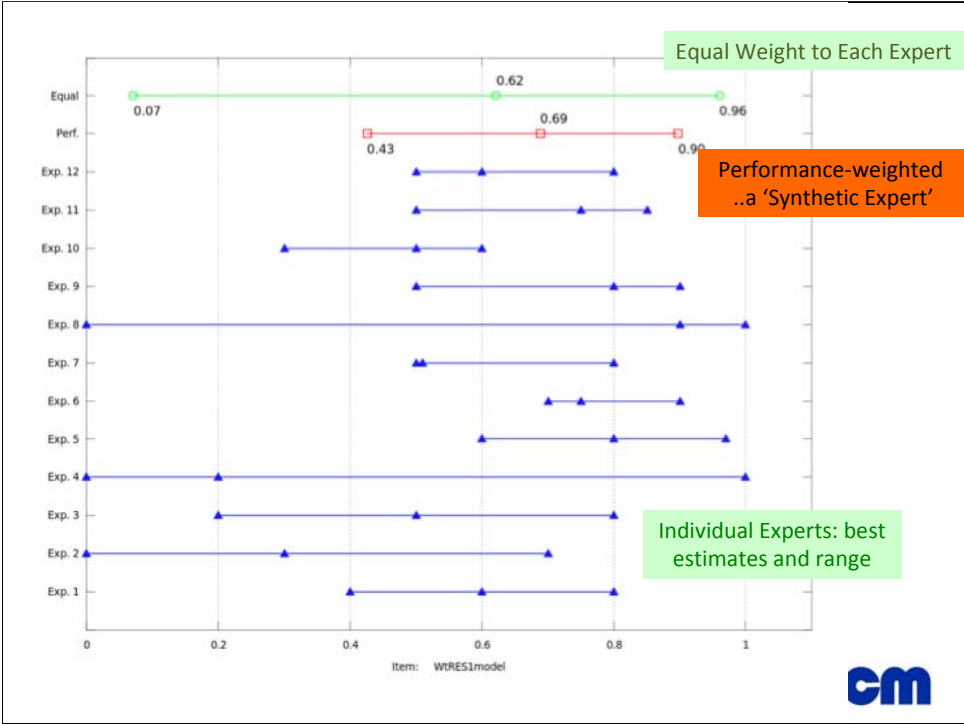
Stylised logic tree to estimate the probability of occurrence of a specific magnitude of volcanic event impact scenario using ITM-Topaz methodology and Expert Elicitation

## EE in Topaz and Wider Applications

Exercise judged successful, achieved main goal of providing a demonstration of a rational and defensible structured expert judgement basis for ascribing initial uncertainty distributions to parameters, models and variables in relation to long-term future volcanic and tectonic hazards and risks.

Identified that could be used in wider tectonic assessments of sensitive facilities: regional or site-specific interpretations of tectonic context; evolution paths of tectonic driving processes over a period of given time; local variations within evolution scenarios; impact of specific magnitude events on critical features or functions of a facility.

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# Topaz – Hazard Map Outputs

- Produce integrated (multiple hazards) hazard maps to identifying locations where uncertainties and risks are either acceptable, or a credible safety case would be difficult to sustain.

- Provide risk informed input to site assessment and consequently to assist in siting and evaluating sites.

- Complex hazard maps can be simplified to produce project management information by defining high, medium and low ranges of hazard. For natural disruptive events, Topaz produced 'Project Risk Maps' that aim to guide NUMO's site selection work, and act as useful communication tools with the public.

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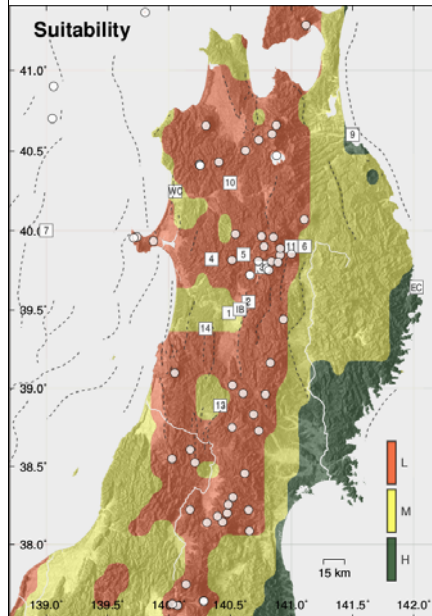
# Project Risk Maps



This example project risk map is designed to indicate areas of suitability with respect to volcanism and uplift.

- Green = high suitability = based on regional and international standards, it is anticipated that volcanism and rapid uplift would have no bearing on site suitability. Such sites are likely highly suitable with regard to these hazards.
- Yellow = moderate suitability = hazards due to volcanism and potential for rapid uplift are low by international standards. It is conceivable that some models result in hazard rates sufficient for detailed study and additional consideration.
- Red = low suitability = some volcanism and uplift models suggest that there may be significant concerns associated with such sites.
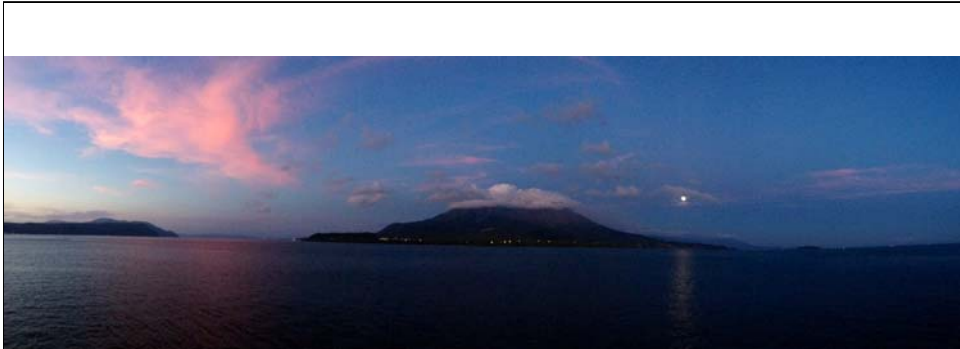
**Any Questions?**

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