WA-6 TECDOC on Volcanic Hazard Assessments for Nuclear Installations: Methods and Examples in Site Evaluations (Task 6.1.1)

Dr. Brittain Hill, Senior Level Advisor
Office of New Reactors
U.S. Nuclear Regulatory Commission

Plenary Meeting of the ISSC Programme
International Atomic Energy Agency
27–31 January 2014

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

General Safety Principle

Smithsonian Institution, 2014

Nuclear installations should not be built by active volcanoes

- Consensus that:
  - Eruptions in last 10,000 yr indicates “active”
  - Young deposits that cover the proposed site indicates “too close”

General Safety Principle

Can volcanoes without eruptions in last 10,000 years represent near-future hazards?

- Need to consider potential for:
  - Future eruption to occur (probability 10^{-4} to 10^{-7} /year).
  - Hazardous phenomena to reach site.
- Consistent with requirements in SSG-21

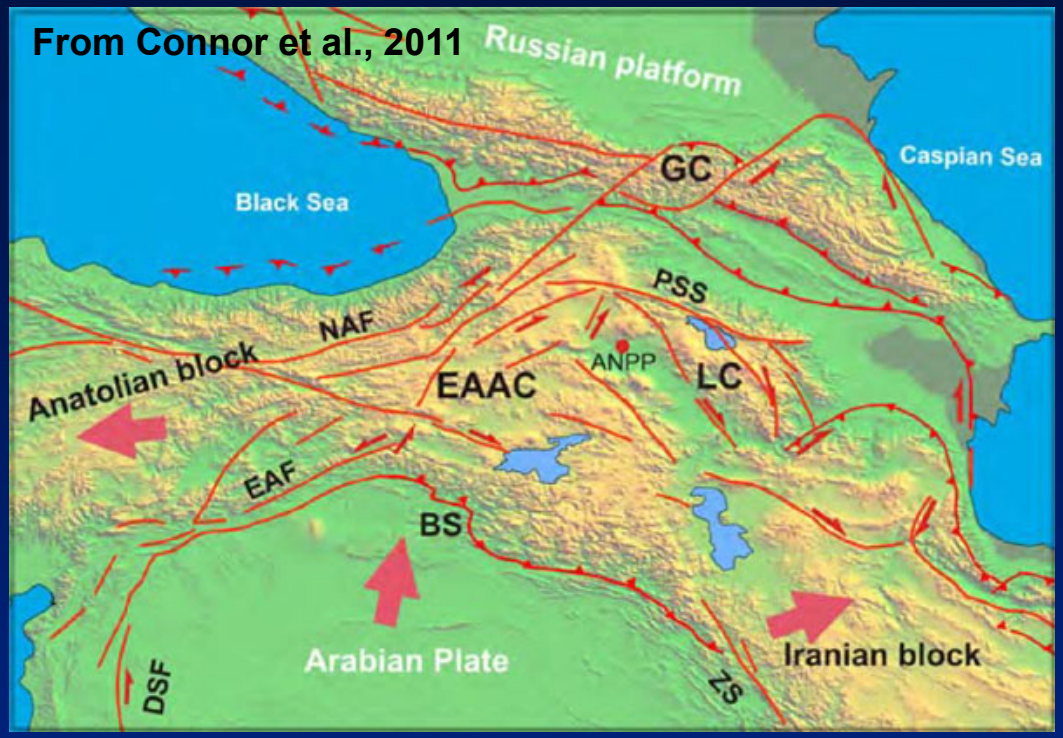
Goals of WA-6 TECDOC

- Estimate likelihoods of eruption occurring
  - Capability for initiating event to 10^{-7} /year
- Calculate magnitude of potentially hazardous phenomena at a site
- Develop mitigation strategies
  - Siting decision
  - Design basis
  - Operational or emergency planning
- Consider needs for volcano monitoring systems

Staged Approach (SSG-21)

- Initial scoping of potential sources
- Hazard screening with available information
- Identify capable volcanoes for detailed analyses
- Evaluate potential for hazardous phenomena to reach the proposed site
  - Consider alternative models
  - Account for data and model uncertainties
- Use results in siting, design and operational decisions

Tectonic Framework



- Volcanic activity can occur for >1,000,000 yrs
- Possible changes in tectonic setting

- Confidence that past patterns of activity can be extrapolated to future, or conditioned.
- TECDOC has specific examples of integrating tectonic framework into hazard assessments.

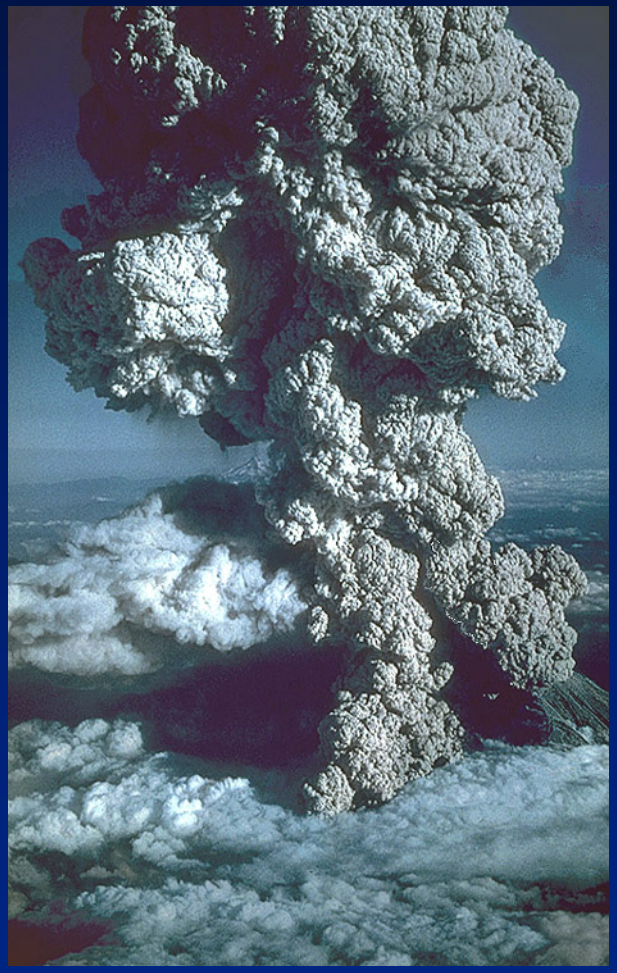
Eruption Recurrence Rates

- Eruptions often are rare and poorly preserved
- Magnitude-frequency poorly understood
- TECDOC emphasizes probabilistic approaches
  - Uncertainties in past patters
  - Spatial or temporal changes
  - Evaluate alternative conceptual models
- Consider deterministic approaches if data support
- Integrate geologic information in models

Hazardous Phenomena

- Each eruption has potential to produce 1 to 11 different types of hazardous phenomena
- For each phenomenon, TECDOC discusses
  - Physical characteristics
  - Potential effects on nuclear installations
  - Models to calculate magnitude of phenomena at site
- TECDOC represents initial stage of developing international consensus on each model's suitability for nuclear safety evaluations

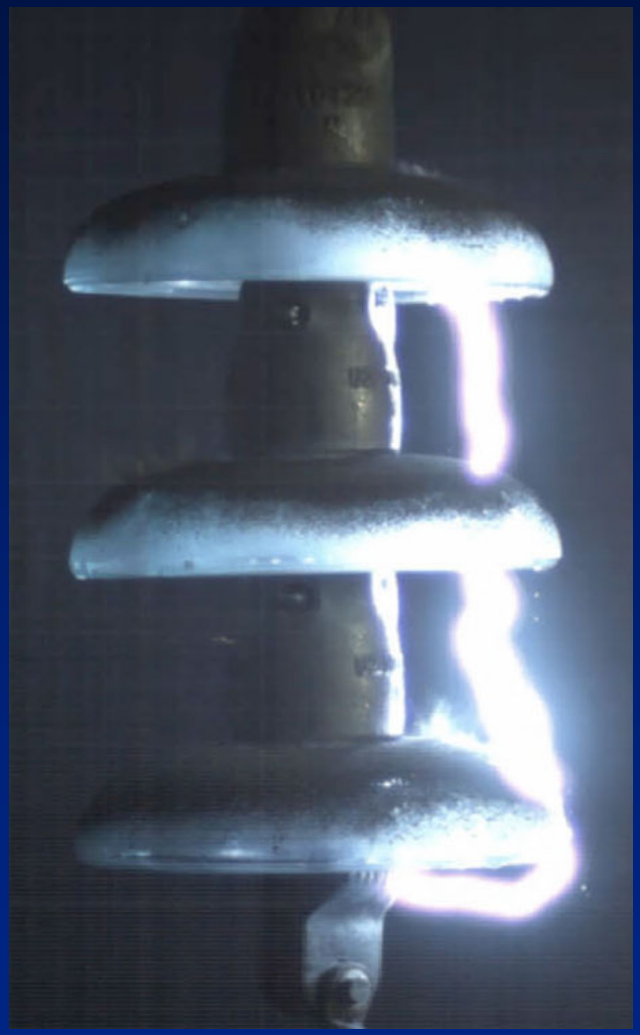
Physical Characteristics of Ash Falls



USGS, 1981

- Ash is hard, sharp rock and crystal fragments to 1 μm size
- Most volcanoes produce ash
- Can travel 10s to 100s of km from volcano
- Dry weight of deposits 10–1000 kg/m^2
- Resuspended (airborne) ash can persist for days to years after an eruption

Ash-Fall Effects on Nuclear Installations

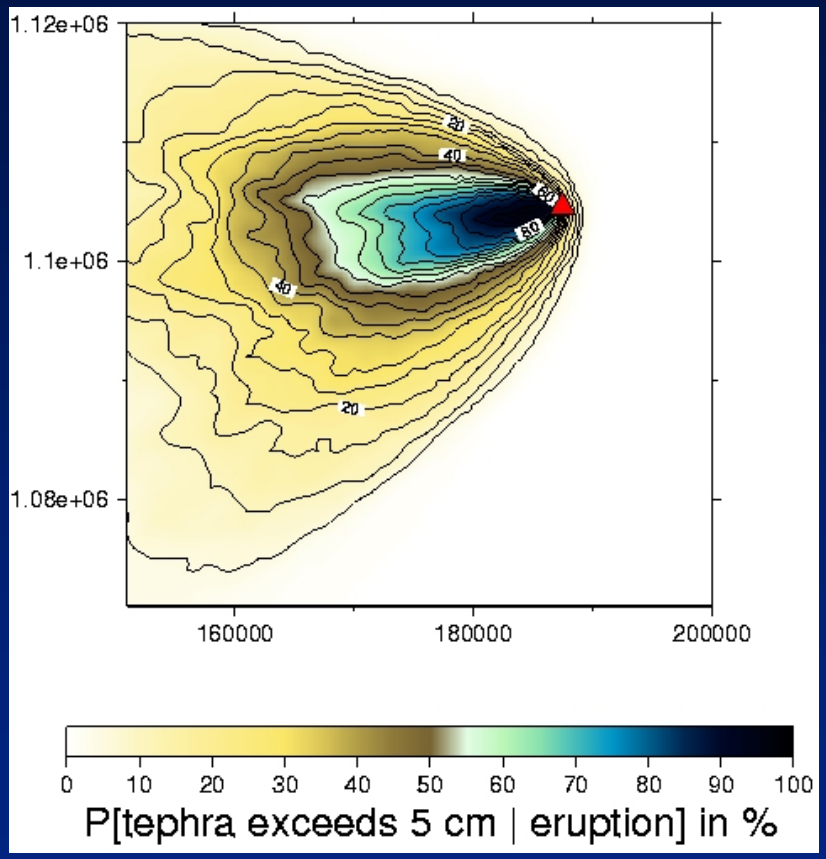


Wardman, 2011

- Electrical conductance if wet
  - Insulator flashover
- Fine particulates can clog air, water, and fuel filters
- Mechanical abrasion
- Static loads

- Can mitigate by appropriate design and operations (i.e., rapid removal)

Calculating Ash-Fall Hazards



- Alternative models
  - Empirical relationships
  - Advective-diffusive
  - Particle tracking
- Dependence on wind-field data
- Includes small, poorly preserved eruptions.
- Develop frequency-magnitude for design

Other Volcanic Hazards

- Generally occur >10 km from volcano:
  - Opening Of New Vents
  - Lava, Pyroclastic, and Laharic Flows,
  - Debris Avalanches and Sector Collapse
  - Volcanic Tsunamis
- Generally occur <10 km from volcano:
  - Volcano Generated Missiles
  - Atmospheric Phenomena
  - Hydrothermal Activity
  - Volcanic Gases

Volcano Monitoring

- Capable volcanoes need monitoring
- Hours to months advance warning
- Multiple techniques available
- Close collaboration with local authorities
- Consideration of false alarms

Summary of Major Accomplishments

- TECDOC demonstrates that volcanic hazards can be analyzed systematically and robustly.
- These analyses can support decisions on site suitability, installation design, and operations.
- TECDOC represents initial stage in building international consensus on hazard models.

- TECDOC now provides a basis to determine “how close” and “how active” a volcano can be near a nuclear installation site

WA-6 Development of a Training Program on Volcanic Hazards Assessment Methodologies (Task 6.1.2)

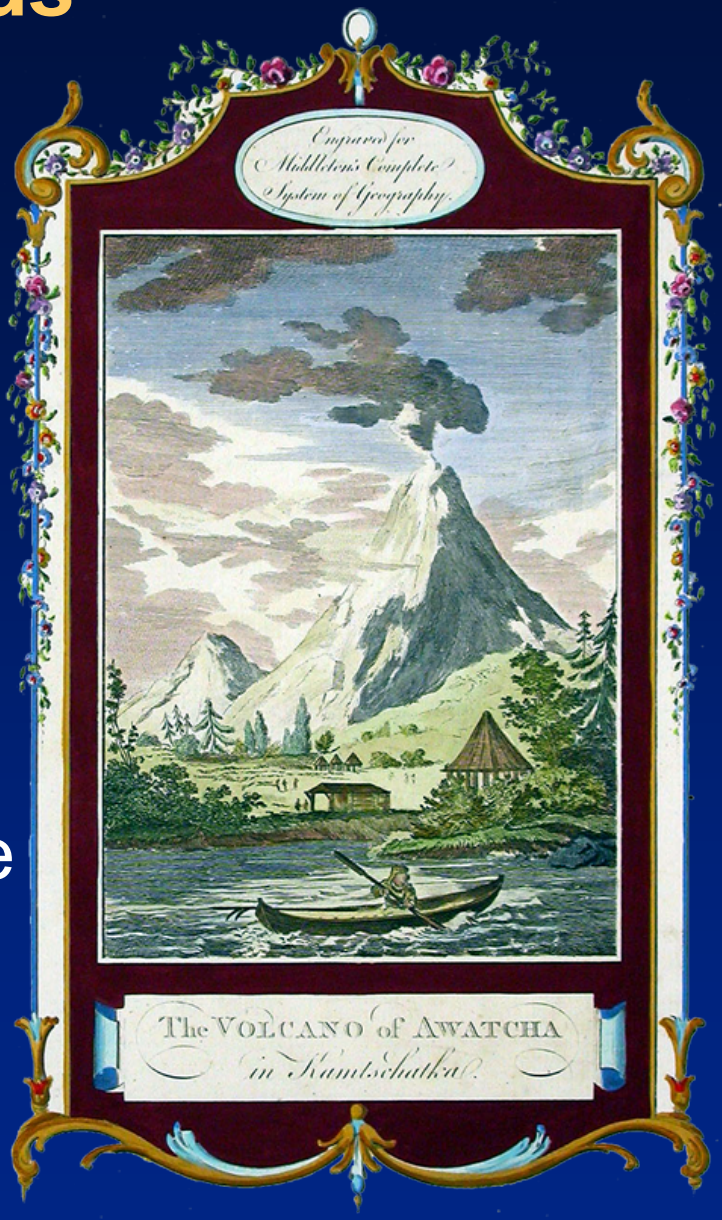
Dr. Brittain Hill, Senior Level Advisor
Office of New Reactors
U.S. Nuclear Regulatory Commission

Plenary Meeting of the ISSC Programme
International Atomic Energy Agency
27-31 January 2014

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

Training Needs

- Practical implementation of SSG-21
- Using results for nuclear regulatory decisions
- Focus on particular hazards in Member State
- Scales from stand-alone course to part of multi-hazard course
- Windows Laptop technology



Module 1: Implementing SSG-21

- Focus on regulatory decision making
- Using the staged approach
- Considerations for tectonic models
- Calculating recurrence rates
  - Deterministic and probabilistic methods
  - Evaluating uncertainties
  - Practical examples and exercises

Module 2: Numerical Modeling

- Focus on ash-fall models
  - Other models as needed by Member State
- Parameterization of field data
- Consideration of data and model uncertainties
- Practical examples and ash-hazard calculations

Module 3: Integrated Assessments

- Potential effects of phenomena on installations
- General approaches for operational mitigation
- Advancing from hazard to risk
- Considerations for model support
- Monitoring programme for capable volcanoes

Module 4: Regulatory Decisions

- Completeness and accuracy of available data
- Basis for screening initial hazards
- Accounting for uncertainties in recurrence rates
- Reasonableness of model support
- Consideration of alternative conceptual models
- Propagation of uncertainties
- Establishing confidence in siting, design, or operational decisions

Approach

- Assemble team of experts (after Plenary)
- Finalize approach, identify primary models and develop individual assignments (2Q 2014)
- Review module outlines, discuss initial exercises and examples (3Q 2014)
- Review drafts materials, test models, integrate modules (4Q 2014)
- Dry runs of modules and final refinement (1Q 2015)

WA-6 Proposal for ISSC-EBP Phase 2 activity

Dr. Brittain Hill, Senior Level Advisor
Office of New Reactors
U.S. Nuclear Regulatory Commission

Plenary Meeting of the ISSC Programme
International Atomic Energy Agency
27-31 January 2014

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

Proposal for New WA-6 Tasks

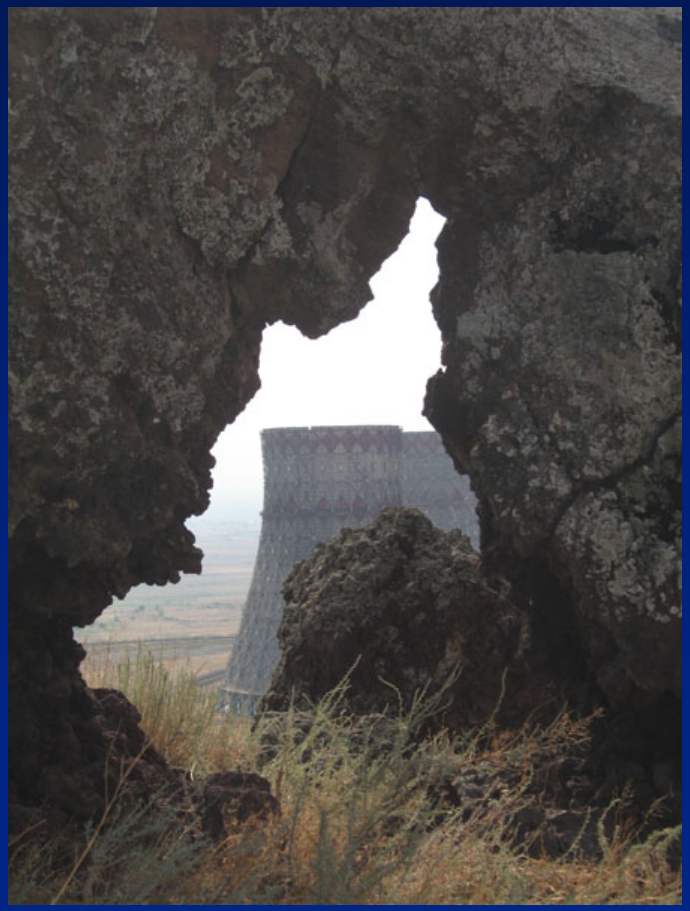
- Technical considerations for design and operational mitigation against volcanic hazards
  - Compilation of international experience
  - Information from analogous facilities
  - Enhanced screening criteria in revised SSG-21

- International consensus on appropriate volcanic hazard models for nuclear safety assessments
  - Similar to modelling for seismic hazards
  - Builds on TECDOC foundation
  - Incorporate consensus methods in revised SSG-21

Questions?

Your own safety is at stake when your neighbor's house is ablaze. Horace

Bataan NPP and Natib volcano



Armenian NPP from Atomakhumb volcano