Physical origins of the uncertainties of predominant input parameters

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Predominant input parameters

There are numerous input parameters used in safety analysis:

> Commonly used are:

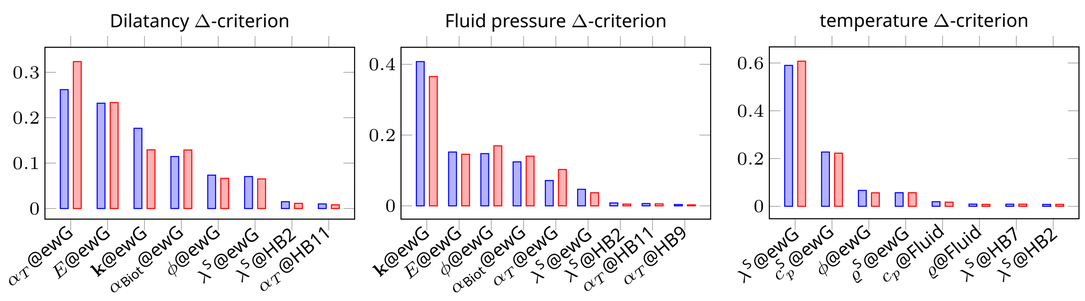
- Volume: porosity ϕ
- Mechanical properties: density ρ; Young's modulus E; strength
- Hydraulic property: permeability k
- Coupling: Biot-Willis coefficient α_{Biot}
- Thermal properties: heat capacity c_p; thermal expansion coefficient α_T; thermal conductivity λ

> Some independent values are taken from databases, e.g. [1].

> Some values are estimated using mixing models e.g. thermal conductivity and density. The uncertainties depend on

- porosity,
- values at 0 % porosity (index s) and 100 % porosity (index f),
- the chosen mixing model.

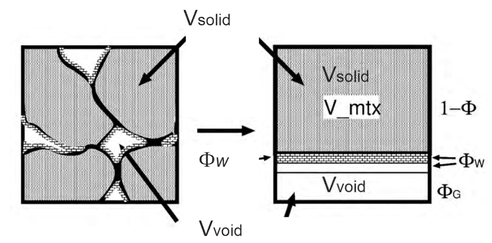
The predominant input parameters depend on the criterion considered:



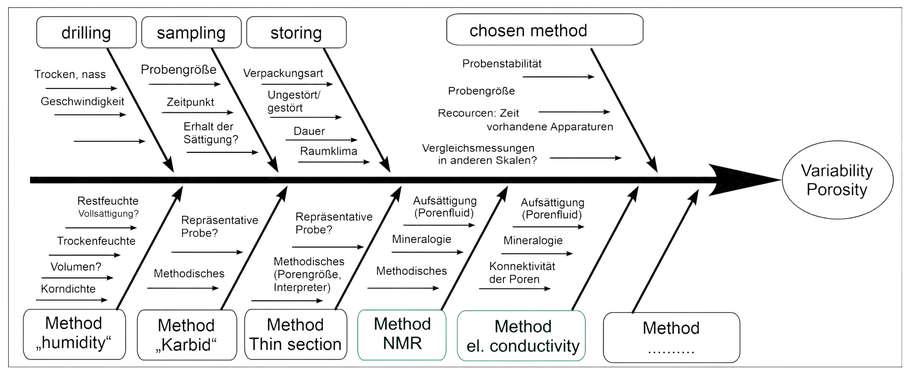
Sensitivity indicators computed from Morris Screening and Sobol variances measuring the increase in dilatancy, fluid pressure, and temperature due to the heat-generating waste. For details, also see the poster by Bittens et al. for this session.

Example Porosity

Porosity is no physical property but a characterization of the ratio of pore (void) volume to total volume. On grain boundaries, the fluid is immobile.



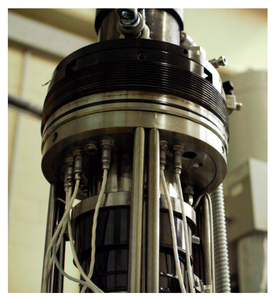
⇒ Porosity used for estimation of e.g. thermal conductivity or density differs from e.g. porosity which is hydraulic effective.



Porosity can be determined using direct or indirect methods. By different methods different volumes in the samples and different portions of the porosity are investigated!

Example mechanical properties

For mechanical properties, next to amount & kind of components and the internal geometry the interaction and by this the thermodynamic conditions (temperature, confining stress, pore pressure) have a significant influence on the experimentally determined values.



Structural and physical dependencies

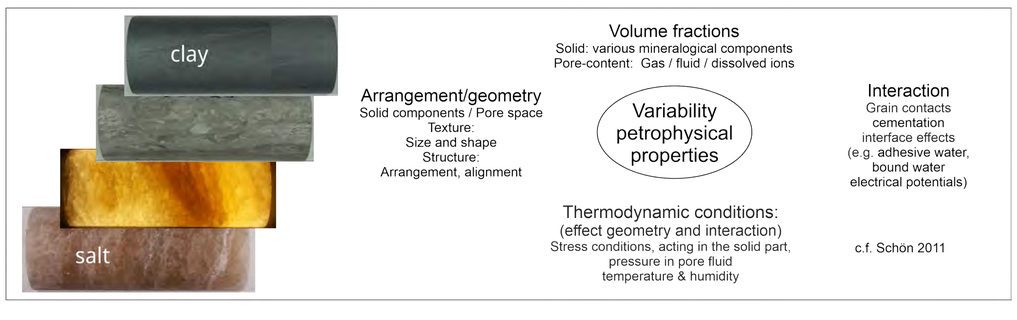
On the one hand, the input parameters (physical rock properties) depend on the rock itself, namely on

a) the amount (described by the porosity) & kind (mineralogical composition, pore content),

b) the arrangement of the components,

c) the interaction of the components,

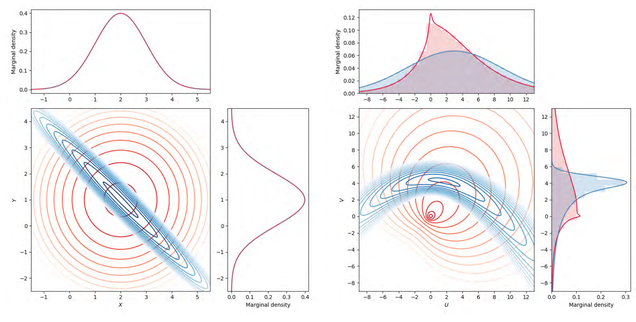
d) the thermodynamic conditions, as they change the interaction of the components, etc.



Influences on variability of physical properties.

Influence of dependencies between parameters

Input: Two different jointly Gaussian distributions of two random variables X and Y. They have the same marginals.
Output: Under the mapping $(X, Y) \mapsto (X^2 - Y^2, 2XY)$, which represents any forward simulation based on X and Y as inputs, the resulting two joint distributions as well as the marginals are very different.



Input Output

Conclusions

Uncertainties are due to

- "sampling" with only quantitative determinable uncertainties
- measurement methodology: aimed to have determinable and small uncertainties,
- variations in lithology, values in databases include "sampling" and measurement uncertainties,
- neglected dependence of input parameters on each other.

Experimental dependencies

On the other hand, the measurement of the input parameters bears uncertainties. The results depend on

- how the samples are drilled, stored and prepared ("sampling"). Uncertainties can be given only quantitatively.
- The method used: the uncertainties (errors) can be quantified and are designed to be significantly lower than the variability of measurement results.

References

[1] D. Jaeggi and P. Bossart. *Kompilation der lithologischen Variabilität und Eigenschaften des Opalinus-Ton im Felslabor Mont Terri*. Expert Report for ENSI. swisstopo, 2014.

[2] J. Schön. *Physical properties of rocks: A Workbook. First edition, online resource*. Vol. 8. Handbook of Petroleum Exploration and Production. Oxford: Elsevier, 2011.

Project and Partners

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