Phase Zero [WP4]
Earth Science, Reservoir, and Data System: Coordination and Communication

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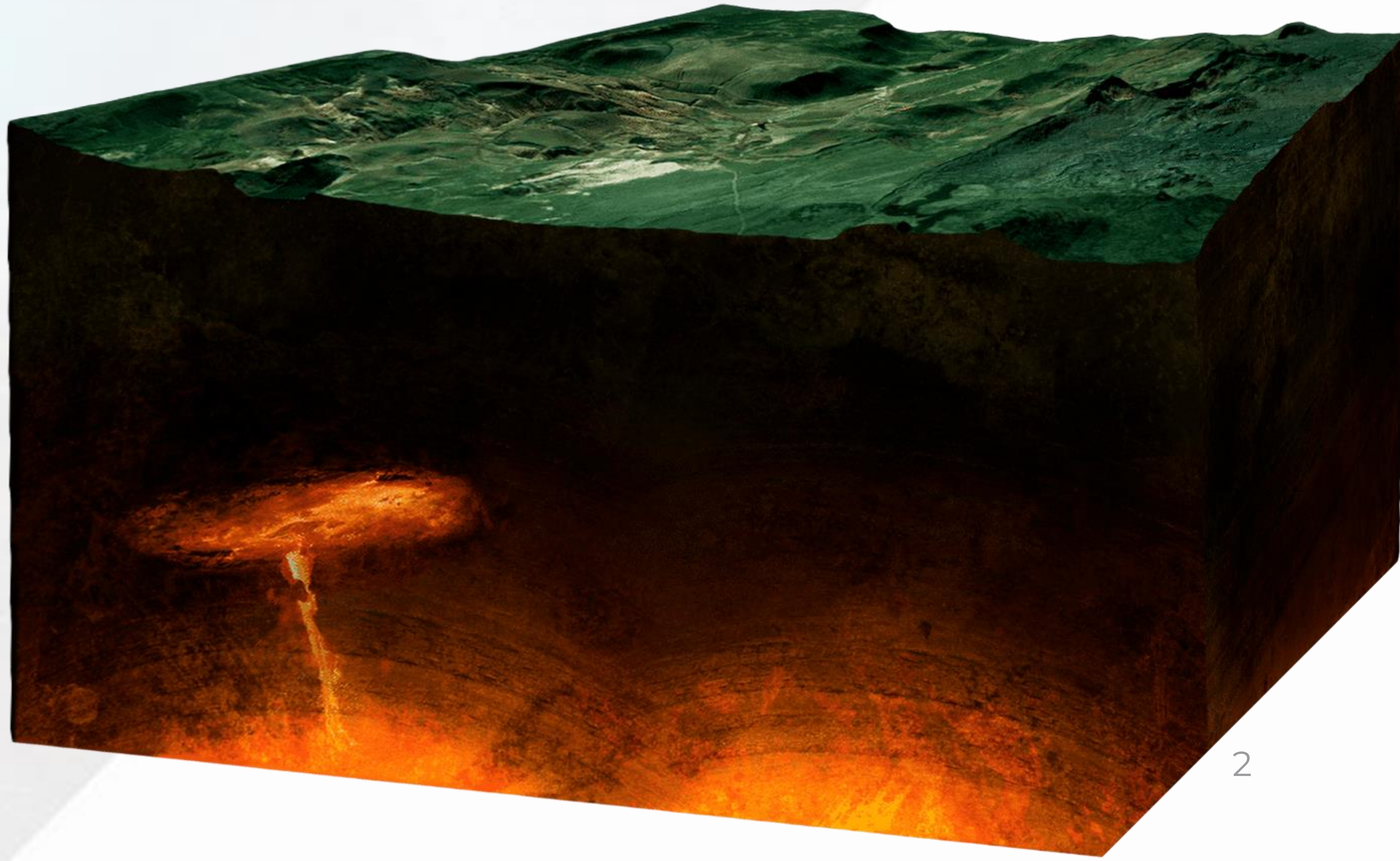
WP4: Earth Science, Reservoir, and Data System

WP Leaders : John Eichelberger / Yan Lavallée

Main objective

Full preparation to obtain samples and data to understand heat and mass transfer through the roof of the magma body and through the response of the magma itself.



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WP4 Tasks

.01 Compilation of existing data and properties of the Krafla system

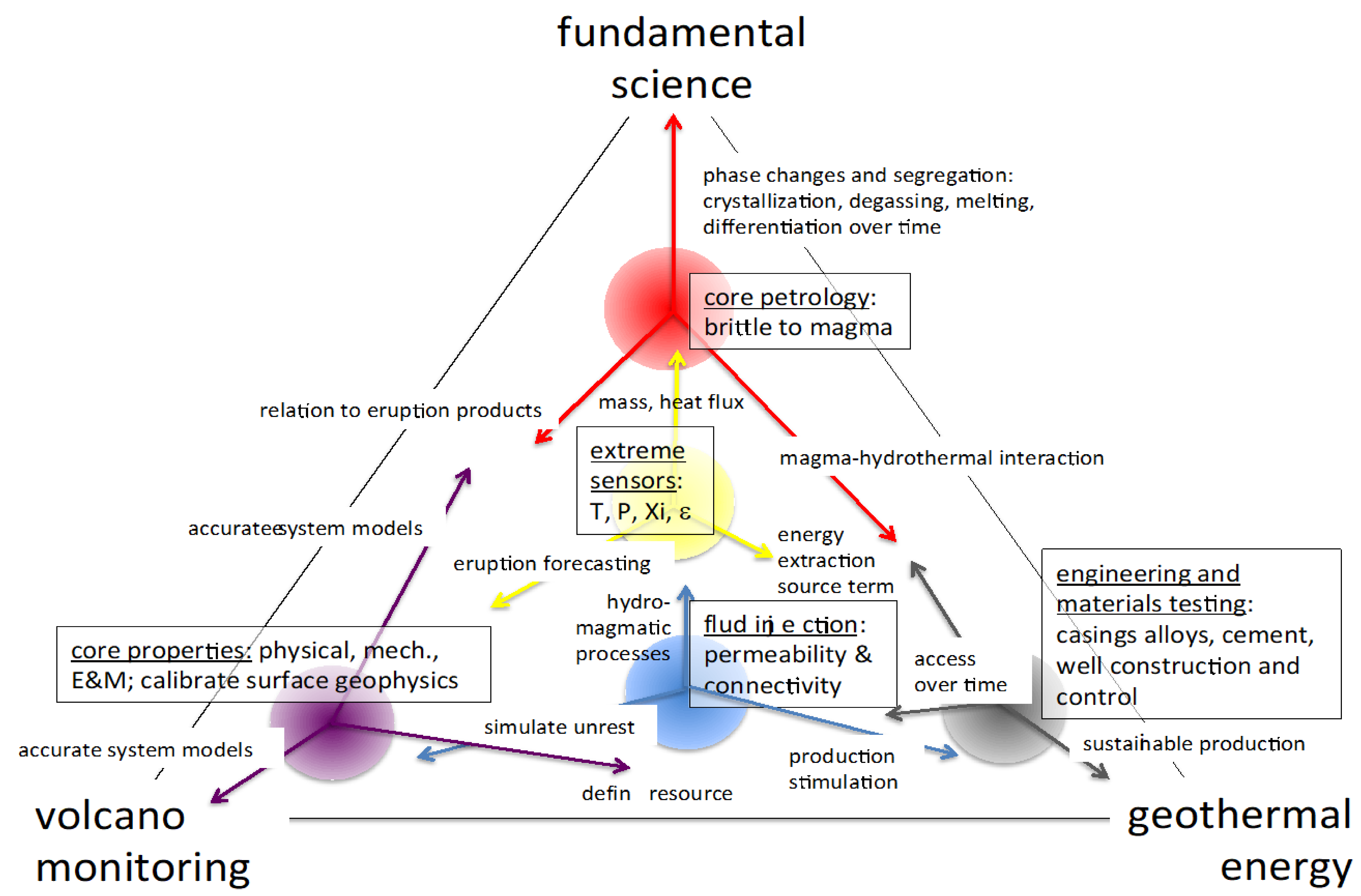
.02 Modelling the impact of drilling into magma

.03 Elaboration of a complete Science Plan, considering different drilling outcomes

.04 Geological risks of drilling into magma

.05 Coordination and synthesis

Three challenges, numerous interdisciplinary opportunities



WP4 Deliverables

D4.1 State of knowledge of the Krafla Magmatic system

- A common database with accessible data sets
- 6 journal articles

D4.2 Comprehensive computational model of drilling into magma

- Identify the favourable conditions for drilling operations
- 3 journal articles

D4.3 Develop a complete, peer-reviewed science plan

- Includes relevant drilling parameters, surface and borehole measurements, sequence of sampling, observations, and experiments.

D4.4 Assessment of geological risks with drilling into magma

- Two-fold: covering volcanic hazards from drilling into magma and geological risk assessment of drilling in hot rocks and magma.

WP4 – The Team

Amel Barich
Coordination Contact

John Eichelberger

Yan Lavallée

WP4 Leaders

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Tasks Leads

Tasks Collaborators

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?

Outcome communicators

(TBD)

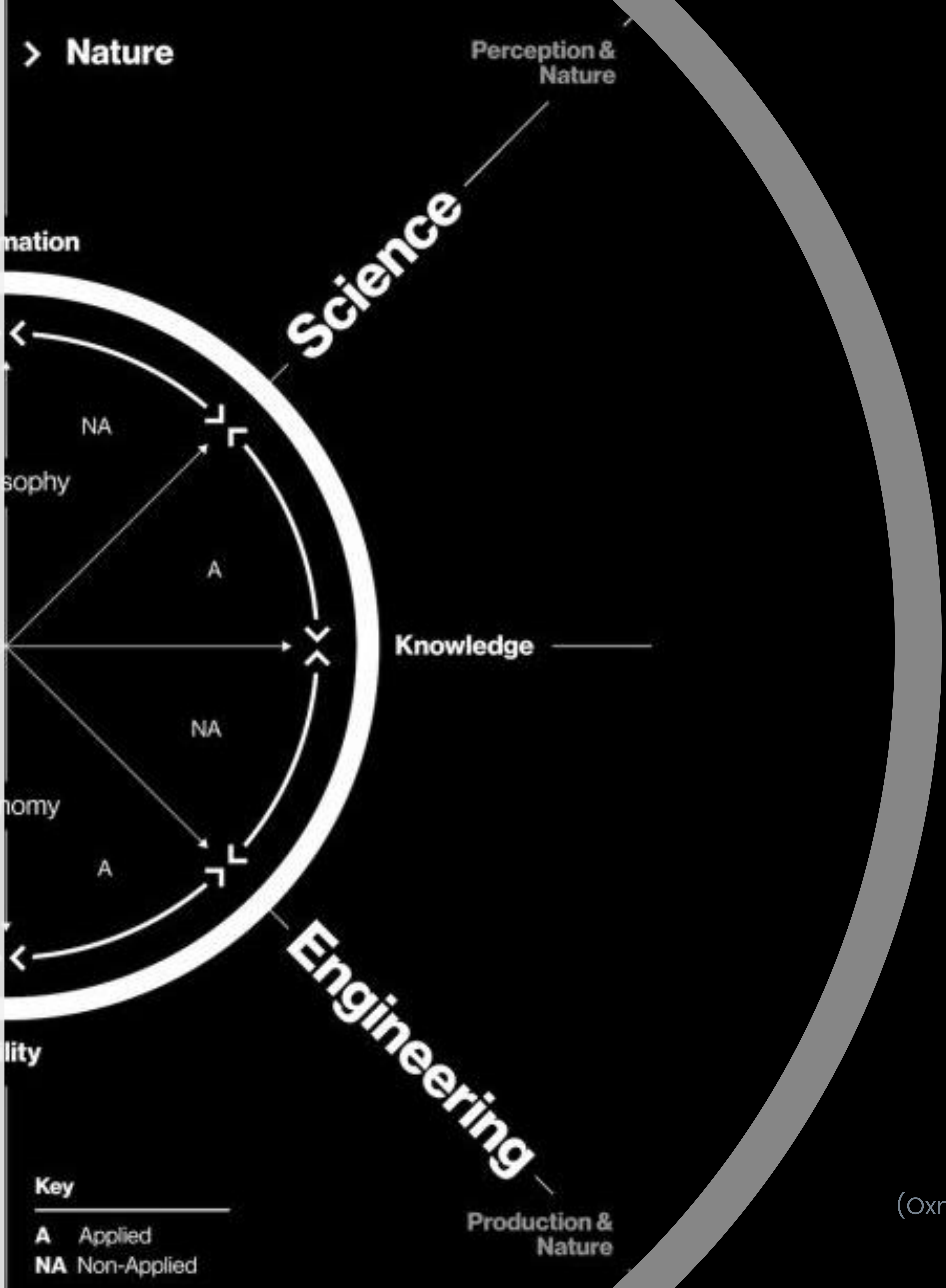
Coordination Challenge:
Synergy between Earth Science (WP4) and Engineering (WP3)

Earth Science.

Engineering.

Coordination Strategy at this stage:

- ➢ Systematic approach
- ➢ Clarity in needs and objectives within and in-between WPs 3 & 4
  - Dichotomize objectives (Intra- and inter-WPs goals)
- ➢ Teams set-ups
- ➢ Synergy enablers
- ➢ Clear Communication Channels



(Oxman, 2016)

Task 4.1 Compilation of existing data and properties of Krafla system

- Surface geology, geological history and observations of recent faulting and magmatic activity in the Krafla area
- Surface manifestations of geothermal activity (and comparison with exposed “fossil” rhyolite intrusions thought to be analogues of Krafla).
- Overview of drilling in the area, location and paths of drill-holes
- Subsurface stratigraphy as well as reservoir parameters (temperature, seismic velocity structure, etc) of the geothermal reservoir from previous drilling efforts at Krafla
- Groundwater flow and model for the area
- Fluid and volcanic gas chemistry measurements in the area
- Constraints from geophysical monitoring surveys of the Krafla system (including seismicity, electrical resistivity, ground deformation (GPS and InSAR), gravity, fibre optics and magnetic fields, etc)
- Physical and mechanical properties of reservoir rock from laboratory measurements (Young’s modulus, strength, Poisson’s ratio, density, fracture density, permeability, etc)
- Physical, chemical, petrology, rheological and mechanical properties of magma encountered in IDDP-1 hole, both in liquid and solid states, as inferred by laboratory studies of quenched magma samples (viscosity, density, chemistry, and volatile content, thermal diffusivity, heat capacity, liquidus and solidus temperature, etc)
- Lessons learned from up-hole flow of magma in IDDP-1 regarding magma properties (including a combined, viscosity and buoyancy evolution model)

Task 4.2 Modelling impact of drilling into magma

- Series of experimental and numerical simulations analysing the characteristics and operational conditions of the well reaching partially melted roof rock and then into magma, through advanced 3D numerical simulations of magma-well fluids, thermo-fluid dynamics and fluid-structure interaction.
- The possibility of magma rise along the well, and the circumstances under which this can happen or be prevented;
- The heat exchange between the magma, the drilling fluids, and the well walls, and the dynamics of fluid flow inside the well;
- Validating and refining novel micro-mechanical model of magma vesiculation pressure development using laboratory testing and integration of the model in large-scale 3D numerical simulations
- The forces acting on the magma-drilling, fluids-drill walls system, and the associated deformation
- Extent of vesiculation and quenching under different scenarios of well condition and drilling parameters.

Task 4.3 Elaboration of complete Science Plan, considering different drilling outcomes

- The science plan will detail strategic progress for the following scenarios of possible drilling outcomes:
- Research plan if core is successfully obtained and magma is reached
- Research plan if core is successfully obtained but no magma is reached
- Research plan if no core is obtained but the magma interface is reached
- Research plan if no core is obtained and magma interface has not been reached
- Research plan if monitoring equipment fails
- Research plan if drilling has to be halted before the target zone equivalent to >2070 m in IDDP-1 (depth where return of cuttings stopped) is reached.

Depending on the scenario encountered, different scientific activities will be described, and tasks allocated to leading experts to facilitate timely progress, optimise potential research outcome and thus ensure success of the project and benefit to the various stakeholders identified.

Task 4.4 Geological risks with drilling into magma

Two-fold: 1) volcanic hazards from drilling into magma and 2) geological risk assessment of drilling in hot rocks and magma.

Include:

- Potential triggering of a volcanic eruption by drilling into magma
    - with consideration of chemistry (rhyolitic vs basaltic) and eruption style (effusive, vs explosive vs phreatomagmatic vs phreatic)
- Assessment of particularly hazardous times to drill magma chamber
    - With consideration of lessons learnt from drilling during vs after the Krafla Fires.
- Risk assessment from emission of volcanic gasses
- Risk assessment of seismic hazards
- Risk assessment for crustal deformation
- Risk assessment for impacting the geothermal reservoir
    - Changing fluid composition and thermal conditions

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Task 4.5 Coordination and synthesis

- Ensure WP goals are reached.
- Ensure consistency and fill gaps among WPs.