MSMEET

Modelling Support for Monitoring Earth Evolution through Time, MSMEET

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In Short

- Geodynamic modelling of mantle convection, crustal production and recycling in the pre- plate tectonics Earth in Hadean-Archean times.
- Modeling of the interaction of deep and surface processes in the evolution of plate tectonics on Earth.
- Modeling of the transition from pre-plate tectonic regime on Earth to the plate tectonics and deciphering potential geochemical signatures of this transition.

1 | Motivation. Despite its fundamental importance, the evolution of the Earth System and feedbacks between its reservoirs (from Earth's core to atmosphere) are not yet well understood, especially on the early Earth. This is primarily because ancient rocks are rare, altered, or lack diagnostic information on the geochemistry of highly mobile elements and volatiles. This limits our knowledge of such critical issues as the compositional evolution of the Earth's mantle and its interaction with the core; the rate of continental lithosphere production and recycling; the onset timing of plate tectonics on Earth and controlling factors of its evolution; and even the origin and evolution of continents, oceans, and life. Moreover, plate tectonics controls mass and heat transfer between deep-mantle, lithosphere and atmosphere at the present time. Despite its unquestionable importance for modern geodynamics, there is still no agreement about when and how plate tetconics started and what controls its evolution through Earth's history [1]. The current project will address these fundamental issues by developing an innovative approach that relies on synergy between geochemistry, petrology, and geodynamics.

The European Research Council (ERC) Synergy Grant is a prestigious and competitive ERC Grant awarded to International groups of researchers addressing fundamental scientific problems. Prof. Stephan Sobolev and collaborators were awarded this grant, named Project MEET (http://www.geology.wisc.edu/∼wiscsims/ERC/MEET/), which began in November 2020. MEET will address the major questions outlined above and offer an unprecedented look at the evolution of Earth from 4.4 Ga to the present day, from the atmosphere to the core. The MSMEET computational project will be focussed on the numerical modelling of the physical processes responsible for the chemical evolution of Earth and therefore will provide modelling support for the ERC Project MEET.

2 | Methods. To achieve our goals, we will use comprehensive numerical tools solving system of geodynamic partial differential equations describing mantle convection and plate tectonics. We will consider two numerical thermo-mechanical fully MPI parallel codes for our modelling: open-source code ASPECT [2] and ETH Zurich code StagYY [3]. The advantage of using the finite element code ASPECT (see Figure 1) is its ability for mesh refinement and flexibility in using strongly non-uniform meshes. The advantage of the StagYY code (see Figure 2) is that this code was already extensively used for modelling of global mantle convection and plate tectonics [4–7]. We are going to test both codes, and finally choose the one that performs better.

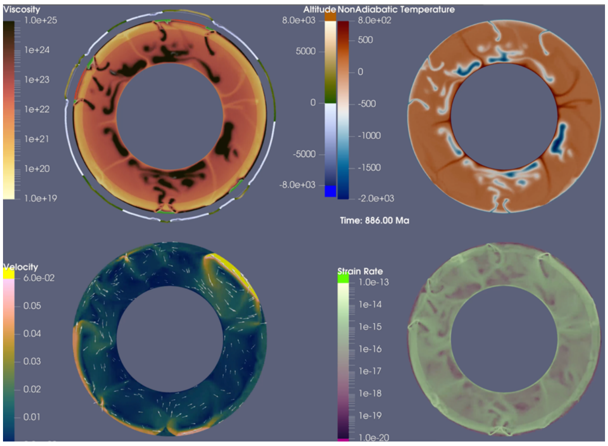

Figure 1: *2D prototype of global convection model with continental rafts in ASPECT.We employ adaptive mesh refinement to track small scale proccesses in the subduction zone channel. Plate boundaries then form self-consistently through the viscoplastic rheology. Building on these models we can begin to understand the stability of continents, subduction initiation and cessation and form a reference model for including surface processes (erosion and sedimentation).*

3 | Goals. The MSMEET project has 3 major goals. Goal 1: Modelling of mantle convection, crustal production and recycling in the pre- plate tectonics Earth in Hadean-Archean times. Recently, Dr. C. Jain has been working extensively with the code StagYY to numerically model the evolution of early Earth. The melting parameterisation in StagYY has been extended to allow for the growth and recycling of continental crust (orange) and oceanic crust (purple) as shown in Figure 2 [7]. These models show crustal production on a global scale in a self-consistent manner for the first time.

Goal 2: Modelling of the interaction of deep and surface processes in the evolution of plate tectonics on Earth. The first part of this goal is the realization of self-organizing models of mantle convection and the associated effects on lithosphere deformation - models that have not been constructed with ASPECT before. Plate boundaries then form self-consistently through the viscoplastic rheology [8]. A 2D proof-of-concept model by Dr. E. Kendall with a visco-plastic rheology and continental rafts is shown in Figure 1. These models will help us to understand the stability of continents, subduction initiation and cessation and form a reference model for including surface processes (erosion and sedimentation). Here, we will investigate the change in sediment flux throughout Earth's history and it's contribution to the development and variability of plate tectonics (postulated to be crucial by [9]).

Goal 3: Modelling of the transition from pre-plate tectonic regime on Earth to the plate tectonics and deciphering potential geochemical signatures of this transition.

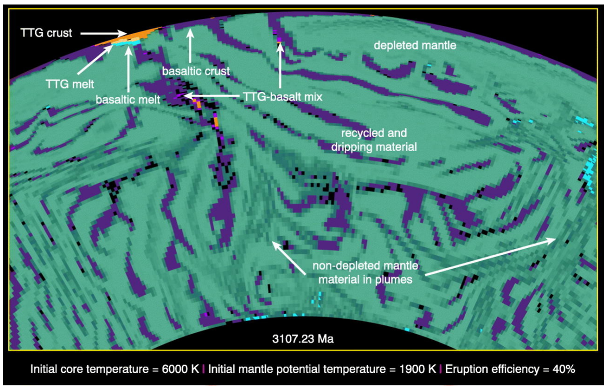

Figure 2: *2D prototype of the production of continental and oceanic crust in StagYY. With these models we can investigate crustal production and recycling in the pre- plate tectonics Earth in Hadean-Archean times.*

WWW

www.gfz-potsdam.de/sektion/geodynamische-modellierung

More Information

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Project Partners

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