Numerical subduction modeling with back-arc temperature heterogeneity using CFD Module

Changyeol Lee (changyeol.lee@gmail.com)
Faculty of Earth Systems and Environmental Sciences, Chonnam National University
33 Yongbong-no Bukgu, Gwangju, Republic of Korea 61186

Introduction: Numerical modeling study using the COMSOL Multiphysics has contributed to the evaluations of the thermal and flow structures of the subduction zones, which are directly correlated to the arc volcanism. Recently, to understand arc volcanisms, consideration of the back-arc temperature heterogeneity becomes much important along with the temperature heterogeneity of the subducting plate. This poster is prepared to demonstrate that the back-arc temperature heterogeneity can explain some of the unexplained arc volcanisms such as Northeast Japan (Quaternary), Kermadec (Quaternary) and Southwest Japan (Cretaceous).

Computational Methods: The CFD module of the COMSOL Multiphysics allows me to consider the back-arc temperature heterogeneity with kinematic or dynamic implementations. Three-dimensional numerical modeling with the clustering computing allows me to conduct a large amount of calculations, which cannot be conducted using a single computer or workstation.

Three-dimensional kinematic-dynamic subduction model: Our subduction model is developed using the commercial finite element package COMSOL Multiphysics. The governing equations consist of equations of conservation of mass, momentum, and energy,

\[ 0 = \nabla \cdot \mathbf{v}, \]
\[ 0 = \nabla \cdot \sigma' - \nabla P + \rho g, \]
\[ \rho c_p \frac{\partial T}{\partial t} = \nabla \cdot (k \nabla T), \]

respectively, where \( \mathbf{v} \) is velocity (m s\(^{-1}\)), \( P \) is pressure (Pa), \( \sigma' \) is deviatoric stress tensor (Pa), \( \rho \) is density defined as \( \rho = \rho_0 (1 - \alpha T) \) (kg m\(^{-3}\)), \( \rho_0 \) is reference density (kg m\(^{-3}\)), \( \alpha \) is thermal expansivity (K\(^{-1}\)), \( T \) is temperature (K), \( g \) is gravitational acceleration vector (m s\(^{-2}\)), \( c_p \) is specific heat at constant pressure (J kg\(^{-1}\) K\(^{-1}\)), \( t \) is time (s), and \( k \) is thermal conductivity (W m\(^{-1}\) K\(^{-1}\)).

Results: Numerical subduction models for the subduction zones were formulated by considering the their subduction parameters and geometries. The back-arc mantle heterogeneity inflowed into the mantle wedge contributes to the thermal and flow structures of the mantle wedge and subducting slab, which explains the temporal and spatial distributions of the arc volcanisms in the studied subduction zones.

Conclusions: The model calculations using the COMSOL Multiphysics show that the back-arc temperature heterogeneity plays a crucial role in the evolution of the thermal and flow structures of the mantle wedge, which is well correlated to the unexplained arc volcanisms in the subduction zones. For details, please contact me through an e-mail.

References: