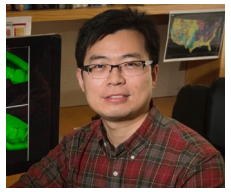
BLUE WATERS
SUSTAINED PETASCALE COMPUTING



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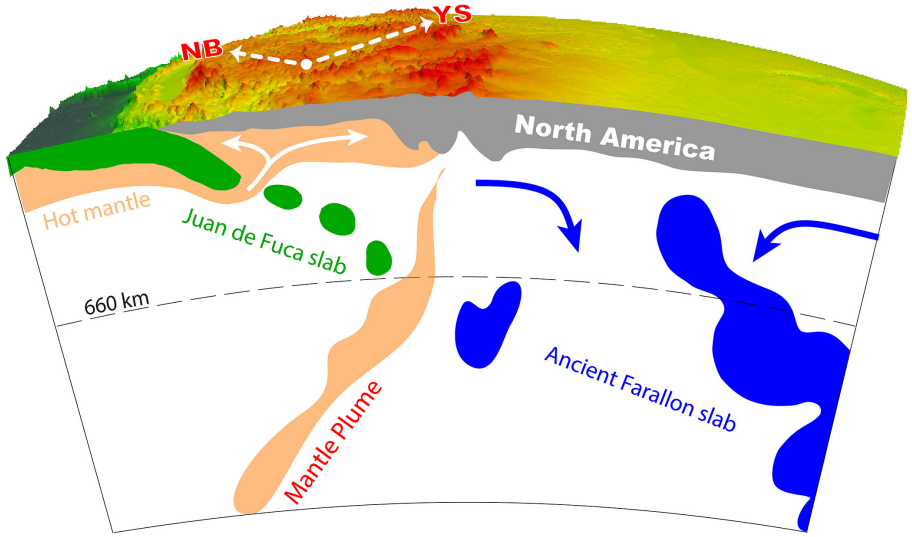
Geoscience

MODELING 4D EARTH EVOLUTION: FROM CONTINENTAL CRATONS TO YELLOWSTONE SUPERVOLCANO

Research Challenge

The challenge geodynamicists face is how to accurately reproduce the various activities within the inaccessible interior of the solid Earth and how to connect them with geological records. To this end, the team's research seeks to answer two questions:

- What causes the most stable portion of continents—cratons—to experience dramatic elevation change and internal deformation?
- What is the ultimate source of heat that fuels the Yellowstone supervolcano?



Schematic view of mantle dynamics below the Western United States. The diverging motion of the hot intruding mantle, corresponding to the Newberry (NB) and Yellowstone (YS) tracks on the surface, is controlled by the sinking Farallon slab (blue) and the retreating Juan de Fuca slab (green).

Methods & Codes

The team uses CitcomS, a community-based finite element code, to simulate a physics-based numerical model of the deep earth. This code, which can be run either forward or backward in time, uses various geodynamic modeling techniques that combine a variety of things such as mantle temperature and viscosity profiles, as well as tectonic plate motion.

Why Blue Waters

The enormous amount of data processing and computation required for this work makes Blue Waters the best platform for the team's research.

Results & Impact

Simulation of the subduction and mantle flow below South America for the past 100 million years revealed that large volumes of the cratonic lithosphere were delaminated into the underlying mantle during the Cretaceous era. This caused the surface to uplift and shed enormous amounts of sediment offshore, leading to thinned crust and deformed lithosphere. This discovery revised the traditional view that the cratonic lithosphere is neutrally buoyant and tectonically stable.

The team also discovered, through modeling of the Yellowstone supervolcano, that most of the heat below the Snake River Plain and Yellowstone caldera originally came from under the Pacific Ocean. This challenges the traditional hypothesis that the Yellowstone supervolcano has been fueled by a deep-mantle plume right below Wyoming.