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What are Mathematical Geosciences? Are Mathematical Geoscientists at the Earth Science Frontiers?

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It might be easy to understand what are a geology, geochemistry, and geophysics as earth science disciplines, but what is Mathematical Geosciences (MG) as a science discipline and how can MG make contributions to critical issues of geoscience might be a question from the public. This is indeed a fundamental question we need to fully appreciate. Mathematical Geosciences is not just applications of mathematics and computers to the geosciences. The author defines MG as an interdisciplinary field merging mathematics, computer and geosciences, MG are sciences of studying mathematical properties and processes of the Earth (other Planets) and prediction/assessment of its resources and environments. Mathematical subjects such as geometry, calculus, functional analysis, probability and statistics provide essential theory and methods to be used in quantitative study of the Earth ranging from geometry and dynamics of the Earth, and uncertainties of measurement, and to observation and prediction of earth events. MG has made indispensable contributions in these fields of geoscience. Examples include but not limit to: the mathematical models of the Earth's shape which serves as the foundation of geodesy, GPS, RS and GIS, a fast growing fields of geomatics; the mathematical modeling of mantle convection serving as the foundation of plate tectonics, the most notable development of earth science in the last century; mathematical symmetry and symmetry operations as principles of mineralogy and crystallography, the foundation of solid earth science; mathematical topological modeling as fundamental in geographical information systems, one of the most useful technologies in geoscience; mathematical and statistical modeling of uncertainty and error bars in isotope geochemistry and the geological time scale; mathematical model and uncertainty of prediction of climate change, the most pressing issue of the geosciences; probability theory and stochastic models of prediction of energy and mineral resources, highly demanded by many nations for economic and societal development; and geo-complexity theory such as fractal, multifractals, chaos and self-criticality for modelling and predicting singular events and extreme phenomenal issues.

What are the current trends of MG and how are they associated with the Earth Science frontiers? Based on recently released publications by several international organizations about trends of scientific research and strategic plans for the next 5-10 years, the author of this paper would present a summary of key topics that can be extracted from the above sources of information to reflect the current trends and frontiers of the earth sciences. The current challenges facing earth scientists are understanding and modeling the geo-complexity of the Earth and environmental systems with their interactions, chaotic nature and predictability of geo-processes, earth singularity and human mitigation and adaptation to extreme events, plus observation and monitoring multiple-scale mixing nonlinear processes. The majority of these frontiers are fundamentally related to MG. This paper utilize the example of fractal density and singularity analysis as example to demonstrate how nonlinear MG can advance in modelling complex earth dynamic systems including energy release at ocean ridges, juvenile crust grow at the continental collision zone, earth quakes, floods and mineralization in the crust. These examples indicate that MG scientists are indeed at the frontier of earth science tackling fundamental problems of the Earth.