Towards A Unified Geomorphology

Robert Wasson
National University of Singapore

Geomorphology is both a physical and historical science, and it can be argued that it should also include biological influences and even co-evolution of the biota, soils and landforms. Landforms are the product of deep Earth processes involving mantle convection and plumes producing plate tectonics, orogeny and epeirogeny. Landforms are also the product of surficial processes of soil formation, denudation, and sedimentation, influenced by seismicity, climate change, and land cover change, with a recent significant role for human agency. In addition processes and rates of change vary with spatial and temporal scale in an interconnected hierarchy. Scaling up from the relatively simple sets of processes that operate at small spatial scale will not provide either an adequate description or understanding of landforms at larger spatial scales. At present geomorphology is not unified, at least partly because of the wide range of phenomena that occur at many different spatial and temporal scales, which are the subject of study in several different disciplines. Also because geomorphology is in part an historical science there is little opportunity for controlled experimentation except by using laboratory analogues and knowledge from physics and chemistry. Conceptual and numerical modeling therefore is a way forward that combines transport laws within the framework of continuity, but models should probably be seen as heuristic devices rather than predictive. Yet there are several examples of linked analyses of phenomena that point to the future where empirical studies are combined with simple physically based models to provide greater understanding. Those that will receive attention in this talk are: the tectonic-climate-erosion-isostasy connection; the tectonic-climate-topography-erosion-river incision connection; and the fluvial-aeolian connection. These connected bodies of understanding look a little like M-theory in physics. That is, a family of different theories each of which is a good description of observations in some range of physical conditions and time periods. But should we step back and ask two fundamental questions: why do we want a unified geomorphology? ; and what would its components be? The answer to the first is that unification, if possible, will provide a much more complete understanding of the surface of Earth and the interconnectedness of its phenomena. And for the second it will be suggested that the following are the required components: continuity, plate tectonics and mantle processes, transport processes and laws including pedogenesis, transport frequency and magnitude, and dynamics both short-term and long-term coupled to estimates of landscape age. It will also be proposed that the most likely analytical framework for a unified geomorphology is system dynamics where causation from drivers to reactions are linked by feedbacks and moderated by delays.