

Royal Swedish Academy of Sciences
2002 Crafoord Prize
in Geoscience

to

Dan P. McKenzie, Cambridge University, UK

For fundamental contributions to the understanding of the Dynamics of the Lithosphere, particularly Plate Tectonics, Sedimentary Basin Formation and Mantle Melting.

The 2002 Crafoord prize is valued at 500 000 US dollars.

The prize will be presented at a ceremony on 18th September 2002.

Plate Tectonics - the fundamental Earth Science paradigm

The Geosciences contribute in three important ways to our understanding of Man's place in Nature. The first is the concept of the VASTNESS of TIME --- the great age of the Earth, as originally conceived by James Hutton, two hundred years ago. The second is EVOLUTION --- the origin and ancestry of Man, as presented by Charles Darwin, half a century later. The third is PLATE TECTONICS --- the fundamental unifying paradigm for understanding the history of Earth.

Plate Tectonics concerns the cold uppermost layer of the Earth, composed of both crust and upper mantle. This layer is called the **lithosphere**; it contains our mineral resources and provides the surface environment on which the biosphere can thrive. Plate tectonics explains the distribution and movement of continents and oceans, the growth and destruction of mountain belts; it controls the Human environment, from the rocks beneath our feet, to the clouds above our heads. The name of Dan McKenzie is intimately tied to the development of this paradigm.

Two important kinds of evidence were essential for the birth of Plate Tectonics. The first concerned an appreciation that continental and oceanic crust have fundamentally different compositions; the second --- that continents drift.

Evidence for continental drift was presented by Taylor and Wegener early in the last century (1910 – 1915) and was for a long time met with general scepticism. It was not until the 1950's, that studies of palaeomagnetism provided independent evidence for the movement of the continents. Thereafter, with the mapping of the bathymetry of the oceans and studies of the composition and magnetic properties of oceanic crust, the scene was set for Plate Tectonics to take over.

At a very early stage in his career, in the mid-1960's, McKenzie wrote key papers about the shape of plates and the kinematics of their movement, providing a robust framework for understanding Plate Tectonics. He was not alone in this part of the Earth Science revolution, but his papers were seminal for the establishment of the paradigm. He described what every school-child now knows, that the Earth's surface is composed of half a dozen vast regions (and a few smaller ones) --- the lithospheric plates. Within these plates there is little deformation; by contrast, the extensional and compressional boundary zones between the plates are the scenes of the real action, with major earthquakes, volcanic eruptions, large displacements and mountain building.

Plate motion is maintained by convection created by the Earth's heat engine. McKenzie's early numerical modelling contributed to the modern foundation for interpretations of the dynamics of this mantle convection. Hot, new oceanic lithosphere is generated at extensional plate boundaries, which are generally manifest as mid-ocean ridges. This young crust stands high in the oceans; as it moves laterally and cools, it subsides to several kilometres depth and eventually collapses, subducting back into the deep mantle.

During the 1970's, McKenzie focused much of his attention on plate boundary deformation, particularly the mountain zones created by the collision of continental crust. His work on earthquake source mechanisms permitted analysis of processes going on deep in the crust in zones of active faulting. His tectonic interpretations of such areas as the Eastern Mediterranean have been of importance for hazard risk assessment in these regions of high population density.

Another aspect of McKenzie's research that has had a great influence on our society resulted in an apparently simple paper written in 1978 "Some remarks on the development of sedimentary basins". It grew out of his interest for extensional deformation within plates and provided a model that has been applied world-wide, with profound economic consequences for the hydrocarbon industry. As basins

subside and fill with sediments, hydrocarbons are generated and fluids flow, laterally and vertically. Cambridge University has been recently rewarded with a 300 Mkr new institute to study multiphase fluid flow in diverse media.

McKenzie's versatility as a geoscientist allowed him to make a remarkable change in focus in the early 1980's. He recognised that the geochemistry of mantle-derived volcanic rocks provides basic information about Earth's convection system. He focused on the quantitative geochemistry of magma melt generation and delved into the fluid dynamics of two-phase flow. His work resulted in papers which have revolutionised our concepts of how melts form, segregate and flow in the mantle and break through to the Earth's surface. This work led to an integration of geophysics and igneous petrology.

Interest in global tectonics, mantle convection and mantle melting on Earth led McKenzie to a closer analysis of the neighbouring planets Mars and Venus. From NASA's Magellan Mission to Venus, he obtained geological and geophysical data that stimulated comparisons with Earth and have led to important inferences about mantle viscosities and compositions.

Interdisciplinary innovation, integrating classical geological observations with geophysics and geochemistry, has characterised McKenzie's career. By bridging the gap between surface tectonics, with its societal impact, and the deeper driving mechanisms, he has established a brilliant, unique position within the world's Earth Science community.

Dan McKenzie was born in 1942 in Cheltenham, England. He obtained his undergraduate and graduate education in Cambridge, UK. He was elected Fellow of Kings College Cambridge in 1965 and obtained his PhD a year later. He was elected Fellow of the Royal Society (UK) in 1976 and Professor of Earth Sciences in Cambridge in 1985. In 1996, he was promoted to Royal Society Professor of Earth Sciences in Cambridge. McKenzie has worked extensively outside the UK for short periods, mainly in the USA. He has been awarded several of the world's most prestigious prizes and is acclaimed by many as the most influential geoscientist of the last half-century.

Crafoord Prize

Anna-Greta and Holger Crafoord's Fund was established in 1980 to promote basic research in mathematics, astronomy, the biosciences (particularly ecology), the geosciences and polyarthritis. Support for research takes the form of an international prize awarded annually to outstanding scientists, and of research grants to individuals or institutions in Sweden. The awards are made according to the order mathematics, geosciences, biosciences, astronomy, geosciences, biosciences, mathematics and so on. The research grant for rheumatoid arthritis is presented every third year, but the prize is awarded only when a special committee has shown that scientific progress in this field has been such that an award is justified. In 2002, the Crafoord Prize amounts to 500 000 US Dollars.