EAG-GS 2017 Outreach Program to Africa

Short course:
Early Earth Life and Mineral Systems

The short course on Early Earth Life and Mineral Systems explores the relationship between surface processes, evolution and habitat of life and the formation of mineral deposits on the early Earth. It investigates the geochemical, mineralogical, environmental and biological evolution of the Earth's surface and immediate subsurface from its volcano-sedimentary record 4.0 to 2.0 billion-years-old. The course focuses on the impacts of the evolution of life on surface processes, geochemical cycles and the formation of sediment-hosted mineral deposits using modern geochemical concepts and techniques.

During the early stages of its history, the Earth was physically and chemically very different from today. The planetary interior was hotter and magmatic and hydrothermal processes were widespread. Continents were free of vegetation and subject to intense chemical weathering. The oceans and atmosphere were anoxic. Large impacts occurred frequently. It was under such conditions that life emerged and evolved.

Apart from rare zircon grains and isolated gneiss outcrops, very little remains from the Hadean (4.6-4.0 Ga) period of Earth history. Eoarchaean (4.0-3.6 Ga) rocks are very scarce and volcanic and sedimentary ones are generally strongly deformed and metamorphosed, retaining virtually no record of the conditions in which they were deposited. Palaeoarchaean (3.6-3.2 Ga) rocks, on the other hand, are better preserved and are present in several crustal domains in Africa, in India and in Western Australia. Palaeoarchaean greenstone belts are direct evidence for non-actualistic tectonic processes on Earth, reflecting secular evolution of the Earth mantle and crust. The volcano-sedimentary successions have recorded very different physico-chemical conditions of the ancient Earth surface, and are the prime target for the study of the co-evolution of the atmosphere, hydrosphere, and biosphere. Although predominantly barren in large ore deposits, gold, and iron locally form important deposits, reflecting specific enrichment processes.

The Mesoarchaean (3.2-2.8 Ga) was a time when the first sedimentary basins formed on stabilized cratonic nuclei, some of which were subjected to tectonic reworking at later stages in Earth history. The Mesoarchaean continental cover succession of the Kaapvaal Craton is the oldest of its kind and includes a large igneous province of bimodal composition and fluvial to shallow-marine sediments. Sedimentary strata provide a well-preserved record of diversified life, contain proxies for atmospheric and ocean composition, and host the largest gold deposit known. Stratigraphic architecture and lithofacies characteristics are not unlike much younger epicontinental volcano-sedimentary successions, but deposition of the strata under predominantly reducing conditions led to non-actualistic ore formation.

The Neoarchaean (2.8-2.5 Ga) supracrustal geological record is characterized by greenstone belts, i.e. curvi-linear, commonly bifurcating outcrop areas of volcano-sedimentary rocks that are wrapped around and/or intruded by different generations of granitoids. They occur in various states of preservation in Archaean cratons, but are also common in some Palaeoproterozoic granitoid-greenstone terrains. They are characterised by submarine, predominantly mafic volcanic rocks that are interstratified or tectonically interleaved with volcaniclastic, siliciclastic and chemical sedimentary rocks of marine to terrestrial environments. Neoarchaean greenstone belts host important mineral deposits, including lode-gold, komatiite-hosted nickel, and volcanogenic massive sulphide deposits. The Neoarchaean saw the stabilization of many cratons, associated with voluminous intrusions of granites, and the development of the first rare metal pegmatites at a large scale.

Early Palaeoproterozoic (2.5-2.0 Ga) intracontinental to passive margin successions were deposited widely on Archaean cratons and record one of the main revolutions of Earth surface conditions, the dramatic increase in atmospheric oxygen level at around 2.3 Ga ago. Linked to the evolution of photosynthesis, this Great Oxidation Event led to rapid mineral evolution, profound changes in continental weathering patterns and major climatic perturbations. The Early Palaeoproterozoic saw the formation of giant sediment-hosted deposits of redox-sensitive elements, including iron, manganese, and uranium. Phosphorite, sedimentary-exhalative, and Mississippi Valley-type deposits made their first appearance in the rock record at that time.