DSPMU UNIVERSITY, RANCHI.
DEPARTMENT OF GEOLOGY

M.Sc. SEMESTER-II **DATE-26/04/2020**

KOMATIITES

Komatiites are rare ultramafic volcanic and subvolcanic rocks that occur, predominantly in Archean and Paleoproterozoic greenstone belts. They are conventionally considered to be derived from high temperature melts of about 1600°C and are assumed to have crystallized from magmas that have about 28–30 wt % MgO.

Komatiites were first identified by Viljoen and Viljoen (1969) in the Archean greenstone belt in the Barberton Mountain land of South Africa as a distinctive and "new" class of magnesium-rich (20–30 wt% MgO) volcanic rocks and hence named them after the Komati River flowing through the type locality. Similar ultramafic lavas were soon described from other Archean and Paleoproterozoic belts particularly from Canada, Africa, Australia and Finland.

MINERALOGY AND PETROGRAPHY

The primary mineralogy of komatiites is simple: phenocrysts of olivine and spinel/chromite (+/- pyroxene) are enclosed in a groundmass composed of glass, calcic clinopyroxene and minor orthopyroxene.

Viljoen and Viljoen (1969), classified komatiites in two groups, based on their composition as peridotitic komatiites (> 24 % MgO) and basaltic komatiites (18 – 24 % MgO), the latter having pyroxenes as dominant phenocrysts.

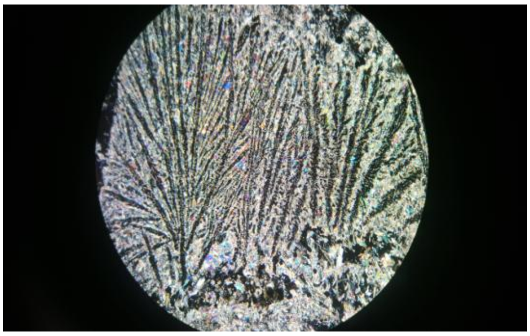
Komatiites and related rocks have been affected to variable degrees by metamorphism, hydrothermal and seafloor alteration, and deformation, which have, at least in part, obliterated the original textures and primary mineralogy. Hence, komatiites generally contain metamorphic minerals in place of their primary assemblages, relics of which may nonetheless be fortuitously preserved in some instances. Low grade metamorphism of komatiites produced mineral assemblages dominated by serpentine–antigorite, chlorite, talc, tremolite, magnesite - dolomite and magnetite. At higher metamorphic grades, metamorphosed komatiites contain anthophyllite, enstatite, olivine and diopside.

TEXTURE

Komatiites are also distinguished from other magnesium-rich rocks, such as picrites, by having distinctive quench textures that were subsequently named “spinifex” (after an Australian spiky grass - *Triodia spinifex*) characterized by spectacular arrays of sub-parallel or randomly-oriented skeletal, platy and bladed olivine crystals set in a glassy groundmass (Figure-1 and 2).

Figure-1

Figure-2



Komatiites often exhibit textural and compositional layering within individual flows which result from their unique fluid properties and composition. The characteristic layering of komatiite flows is produced during crystallization of ponded lava. Polyhedral olivine grains, which were present before eruption or crystallized during flowage, settle to the base of the flow or crystallize in situ to form the lower cumulate layer (Figure 3). At the same time, the spinifex-textured upper part of the flow crystallizes through downward growth of crystals from the crust of the flow.

Spinifex-textured flows have a chilled flow-top (A1) containing a small proportion of solid olivine phenocrysts and a larger proportion of skeletal hopper olivine grains in an augite-glass matrix. Underlying the chilled zone is spinifex-textured lava, Ross & Hopkins (1975) recognized two zones, an upper zone (A2) containing relatively small randomly oriented chain-like crystals, and a lower zone (A3) in which larger platy crystals are arranged in intersecting, upward-pointing cones.

The lower cumulate section (B zone) of spinifex-textured flows is enriched in polyhedral or rounded or less commonly, elongate skeletal grains of olivine. The uppermost part (B1) contains hopper grains oriented rougbly parallel to the flow top. In some flows, a knobby weathering zone (B3) that contains irregular patches of pyroxene-glass matrix material occurs part way through the olivine cumulate zone, dividing it into two similarly textured divisions (B2 and B4), each of which contains polyhedral or granular olivine in a sparse Augite-glass matrix.

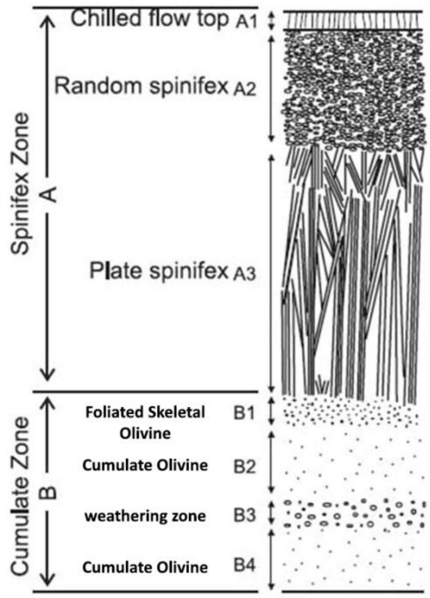


Figure 3- Textural variation in a Komatiitic Flow.

GEOCHEMISTRY

According to their chemical composition, komatiites are usually subdivided into two major types - aluminum (Al)-undepleted (or Munro-type, named after their type locality in the Abitibi greenstone belt) and aluminum- depleted (or Barberton-type).

Al-undepleted komatiites (AUK) are characterized by ratios of Al_2O_3/TiO_2 ~ 20 and CaO/Al_2O_3 ~ 1, values that are similar to those of chondritic meteorites and primitive mantle. Their REE patterns are typically slightly depleted in LREE and have a flat HREE segment with $(Gd/Yb)_n$ ~ 1 (n-chondrite-normalized).

Al-depleted komatiites (ADK) are lower in Al_2O_3 and have low Al_2O_3/TiO_2 (~ 10-12) but high CaO/Al_2O_3 (~2–2.5). Their REE patterns have fractionated HREE with $(Gd/Yb)_n$ >1.3. ADK have higher contents of strongly incompatible trace elements (Th, LREE) than the AUK but their mantle-normalized patterns typically show small negative Zr and Hf anomalies.

The Nd isotopic data on relatively fresh komatiites as well as their fresh pyroxenes from the Abitibi belt yielded Nd values of about 2.8 to 3.8.

PETROGENESIS

Al-undepleted komatiites are thought to be produced by a large amount of melting of a garnet peridotite leaving only olivine (+/-or orthopyroxene) in the residue. Alternatively, AUK could have been generated by melting of a garnet-free source either at a shallow depth (above the garnet stability field; < 3 GPa) or at great depth, below the mantle transition zone (> 660 km) where perovskite (a major silicate mineral in the lower mantle) becomes the major mantle phase.

SIGNIFICANCE

Of great significance is the fact that 3.47-billion-year-old carbonaceous sediments, in places interlayered with komatiites, contain the earliest forms of life known on our planet. These life forms occur as biomats and resemble present-day algae and cyanobacteria. The link between them and the nutrient-enriched environment supplied by the komatiite lavas is compelling.

Komatiites provide a window into the composition and thermal dynamics of the Archean mantle. In addition to the information they provide about the tectonics and the thermal evolution of Archean Earth, komatiites are economically important because they host locally significant magmatic Ni-sulfide (Ni-Cu-PGE) mineralization. Famous deposits include those in the Archean Yilgarn and Pilbara cratons of Western Australia, the Abitibi greenstone belt, Zimbabwe craton, the Proterozoic (1.8 Ga) Cape Smith (Ungava) belt of Québec and the Proterozoic Thompson belt of Manitoba. A close genetic relationship between gold mineralisation in greenstone belts and, in particular, the Barberton Belt and komatiites, has also been shown to exist and exciting new concepts are developing.