

## Exotic Lavas: Komatiites and Carbonitites

GLY 424/524  
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## General Characteristics

- Old
  - Hadean/Archean
    - 3.0 - 3.5 Ga
    - 2.7 - 2.9 Ga
  - Found in cratons, greenstone belts
    - <10 vol%
- Ultramafic
  - 18 wt% MgO
  - Implies
    - High eruption temps
    - Low eruption viscosities

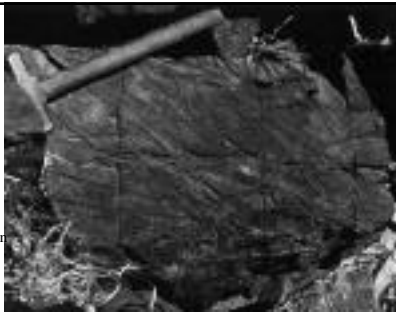
## General Characteristics

- Source
  - High amounts of mantle partial melt (~30 - 80%)
  - Tails of Archean mantle plumes?
- Composition
  - Olivine (spinfex texture)
  - Orthopyroxene
  - NO clinopyroxene

## Physical Characteristics

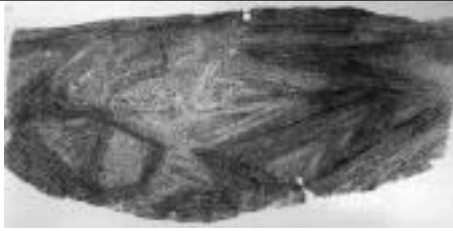
- All inferred based on composition, crystal content
- Hot
  - 1360 - 1600°C (~1630 - 1870K)
  - Spinfex = quenched olivines?
- Low-viscosity
  - 0.1 - 10 Pa s
  - Turbulent?

Coarse olivine spinifex from a thick (8 m) Barberton komatiite cooling unit. Rock face shows bladed olivine spinifex crystals (recessively weathered because olivine has been altered to serpentinite) > 30 cm long. This coarse texture develops in the slowly cooled flow interior, and is developed with this texture to a depth of 4 m. Hammer in photo is 50 cm long.



Barberton olivine spinifex komatiite. Top of photo is within 10 cm of chilled margin. Bladed olivine spinifex crystals show up as dark shadows revealed by differential weathering of the serpentine that replaced olivine. Max length of olivine blades is 20cm. Resistant material is pyroxene and spinel that crystallized later and filled in between the olivine blades. Thermobarometry of this pyroxene indicated emplacement conditions of less than 1400°C, 200 MPa and 4 - 6 wt% dissolved H<sub>2</sub>O. Camera cap in photo is 5.5 cm.



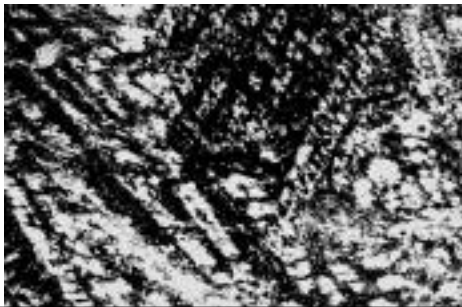


Thin section through the coarse-bladed olivine spinifex zone in the slowly cooled interior of komatiite unit. Sample is ~0.5 m from upper chill margin. The long, dark stripes in the thin section outline the shapes of olivine (now altered to serpentine and magnetite) blades ~15 cm long in this portion of the unit. The lighter-colored triangles and quadrilaterals contain tremolite, chlorite and magnetite and represent regions where spinel and high-Ca pyroxene crystallized after the early olivine blades.



Thin section through the coarse-bladed olivine spinifex zone in the slowly cooled interior of a komatiite unit. Sample is ~0.5 m from upper chill margin. The long, dark stripes in the thin section outline the shapes of olivine (now altered to serpentine and magnetite) blades ~15 cm long in this portion of the unit. Lighter-colored triangles and quadrilaterals contain tremolite, chlorite and magnetite and represent regions where spinel and high-Ca pyroxene crystallized after the early olivine blades.

### Spinifex microphotograph



### More spinifex



### Komatiites: Thermal/mechanical Erosion

- Perserverence, W. Australia
- Komatiite channels
  - 1 km wide
  - 100 - 150 m deep
- Some interpretations include:
  - lots of thermal erosion (felsic tuffs as substrate)
  - Liquidus/superheated lavas
  - Channels 10's - 100's km long
  - Volumes ~103 km<sup>3</sup>

### Carbonatites



Oldoinyo Lengai, Tanzania: summit crater ~400 m

## Carbonatites: Characteristics

- Igneous rocks
- >50 wt.% carbonate minerals
- 350 known occurrences
  - Mostly intrusive
  - >50% of occurrences in Africa
  - Closely associated with rift zones

## Carbonatites: Types

- Calcicarbonatites
- Magnesiocarbonatites
- Ferrocarnatites
  - All the above contain calcite, dolomite and ankarite
- Natrocarbonatites
  - Oldoinyo Lengai only known occurrence
  - >30 wt.% Na<sub>2</sub>O
  - Contains nyerite and gregoryite

## Carbonatites: Genesis

- Mantle origin
- Silicate-carbonate immiscibility
  - Experimental data show that
    - Natrocarbonatites & calcicarbonatites can form via liquid immiscibility from silicate magmas
    - Magnesiocarbonatites form as primary magmas or via fractionation of calcicarbonatites
  - CO<sub>2</sub> plays important role

## Carbonatites: Properties

- Cool
  - Not incandescent (barely so at night)
  - Eruption temperatures = 500 - 800°C
- Low viscosity
  - Lowest of any magma/lava
  - 0.005 Pa s - 85 Pa s
    - Higher viscosities = more crystals
    - Newtonian fluids
- Low density
  - ~2000 - 2500 kg/m<sup>3</sup>

## Carbonatite Morphologies

- Similar to basalts
  - A'a-like, pahoehoe-like
  - Sheets, channels
- Chemistry makes thermal erosion very easy
- Looks like flowing mud

## Oldoinyo Lengai



## Oldoinyo Lengai



## Planetary Occurrences

- Komatiites
  - Mars?
  - Venus
    - Canali
    - Outflow channels
- Carbonatites
  - Venus
    - Canali
    - Valley networks

## References

- Williams et al., 2001, Analytical/numerical modeling of komatiite lava emplacement and thermal erosion at Perseverance, Western Australia, *JVGR* 110:27.
- Dawson, J.B., H. Pinkerton, G.E. Norton and D.M. Pyle, 1990, Physicochemical properties of alkali carbonatite lavas: Data from the 1988 eruption of Oldoinyo Lengai, Tanzania, *Geology* 18:260.
- Bell, K. and J. Keller, eds., 1995, *IAVCEI Proceedings in Volcanology 4: Carbonatite volcanism of Oldoinyo Lengai--Petrogenesis of Natrocarbonatite*, Springer-Verlag, Berlin.

## More references

- [http://www.nrcan.gc.ca/cgc/mrd/pub/carbonatites\\_e.html](http://www.nrcan.gc.ca/cgc/mrd/pub/carbonatites_e.html)
- [http://www.nmnh.si.edu/gvp/volcano/region02/africa\\_e/lengai/var.htm](http://www.nmnh.si.edu/gvp/volcano/region02/africa_e/lengai/var.htm)