MSc (second semester)

Elective paper

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Early Earth , Magma: primary Differentiation process

- Oxygen in the form of the oxygen molecule (O_2), produced by plants, and vital for animals, is abundant in present day Earth's atmosphere and oceans. However, it was relatively scarce for much of Earth's 4.6 billion-year existence
- By studying ancient rocks, it is understood that sometime at about 2.5 billion years ago, oxygen has been abundantly available in the atmosphere ever since through Earth's processes, called the "Great Oxidation Event" (GOE).
- The story of the early earth i.e nearly first 2.0 billion years (4.6-2.5 billion years) constitutes nearly half of the geologic time .

- This history encompassing evolution of earth during this period is locked in the ancient rocks and its constituent minerals.

The Hadean Time >4000 Million Years

The Cryptic "Era" – 4.56 to 4.1 Ga

Cryptic because not much geological evidence on Earth has survived to the present day.

Correlative to the Early Bombardment Phase of Earth/Moon history

Late Bombardment Phase 4.1 to 3.8 Ga (beginning of Archaean Eon).


Early in Earth History the Planet
Developed a Magma Sea
4.5-4.0 billion years ago
Early Earth began to heat as the last extraterrestrial collisions subsided
1. Rock is a good insulator – stores heat
2. Collisions produced heat that was stored
3. Radioactivity
4. Gravitational contraction
What is the physical consequence of melting a homogeneous ball of rock?
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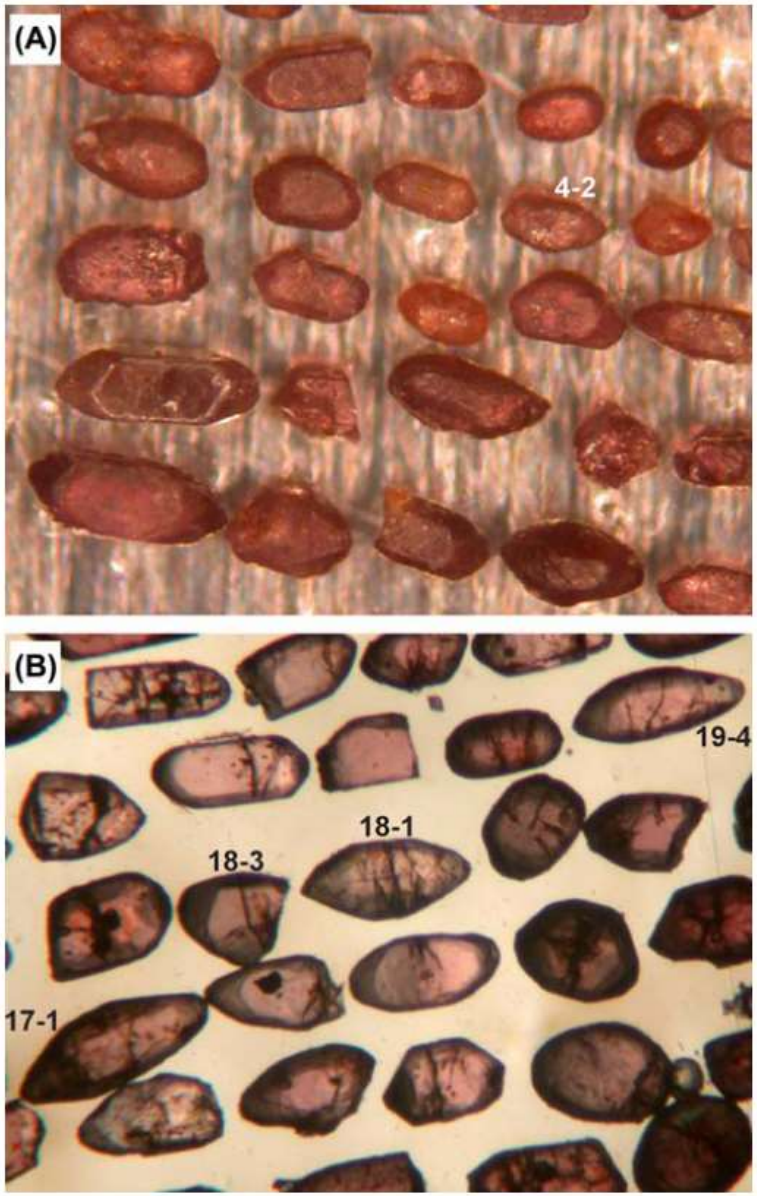
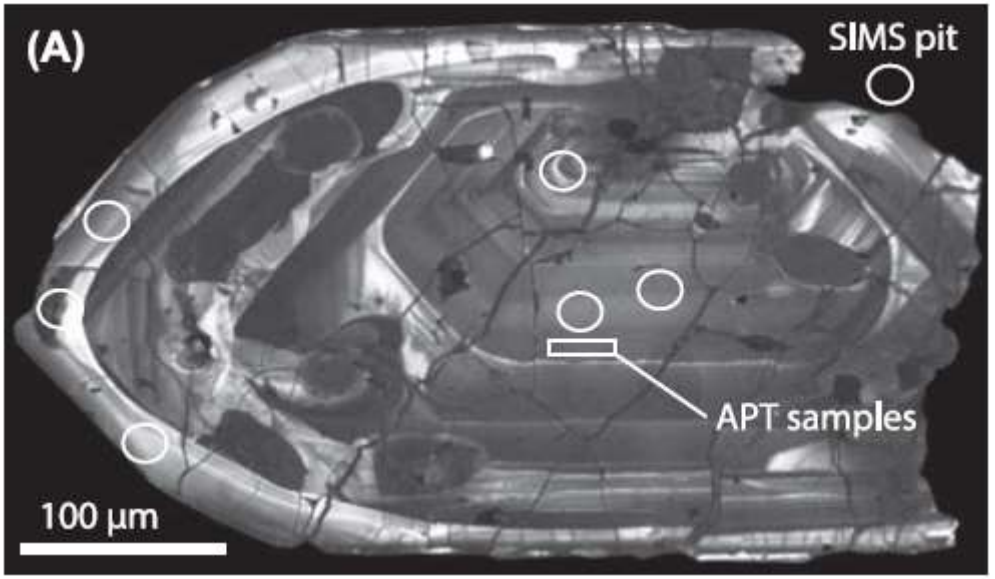
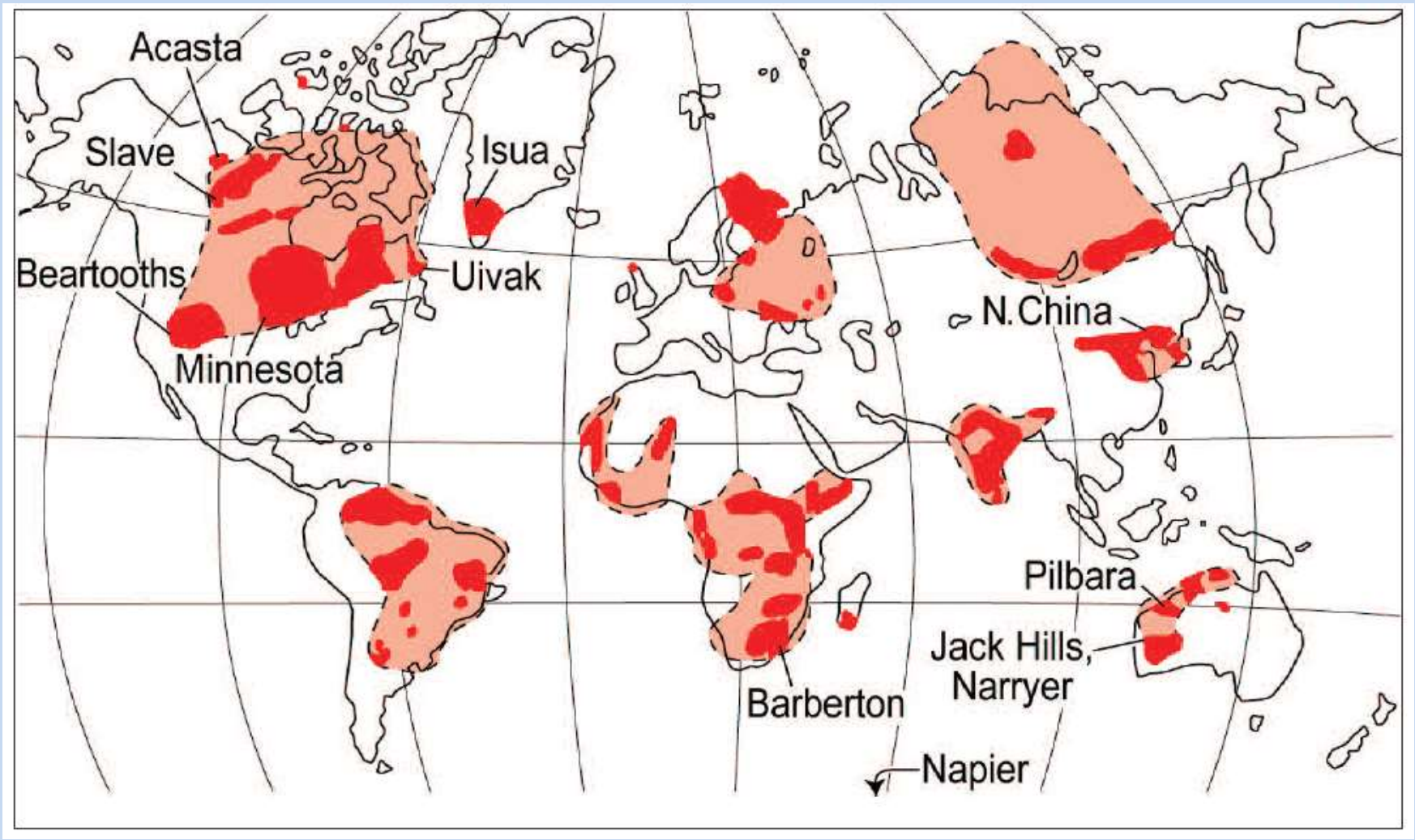
Zircon in oldest rock: clue to Hadean time



Some of the oldest zircon crystals



- Oldest zircon from the Jack Hills of Australia, indicate granitic rocks may have been forming since 4400 million years
- U-Pb dating of the oldest zircon crystals (like the one above) reveal that continents arose just 160 million years after our solar system formed, much earlier than previously thought.



Valley et al , 2006

FIGURE 3 Map showing known (dark orange) and suspected (light orange) areas of rocks older than 2.5 billion years. Areas with >3.6 Ga rocks or zircons are labeled by name.

Hadean zircons in India

4200 Ga zircon in a granitoid gneiss near Champua in Oddisa

both U-Pb ages and Lu-Hf isotopes in zircon are resistant to other geologic processes and disturances

Implication: crustal growth started in early earth well in Hadean time

Archaean (2.5-3.6 Ga) or even older komatiitic rocks

mantle differentiation

- Komattic rocks are produced from very high temperature (1500-1600C) ultamafic magma
- Mafic mineral like olivine (Mg, Fe SiO4) is common in the rock
- Rock characteristically develop spinifex texture-long intersecting sheefs of olivine

Early mafic magmatism and mantle Differentiation

High temperature mantle-derived magma crytsllaized to form in early earth

Mantle melting must have een taking place since very early time

High temperature magma production indicates mantle differentiation started very early in the evolution of the earth.

Komatiitic magma have produce komattitic asalt during crytsallization y fractionating olivine (frcational crystallization).

Production and eruption of comparatively lower temeprature asaltic magma (1200-1350 C) ecame more common in late-Archean-palaeoproterzoic time (2700-2400 million years)

However, very old ~3.59 Ga gabbros (compositonally similar to asalt) encountered in the Pilbara Craton (Australia)

Schematic view of some processes in basalt formation