

500 million years of episodic granite magmatism in the Archean Yilgarn craton

Paul Sylvester, John Myers, Jim Crowley, Kate Souders
Department of Earth Sciences
Memorial University
St John's Newfoundland

Penrose Conference - When did Plate Tectonics Begin on Earth?

Friday June 16, 2006

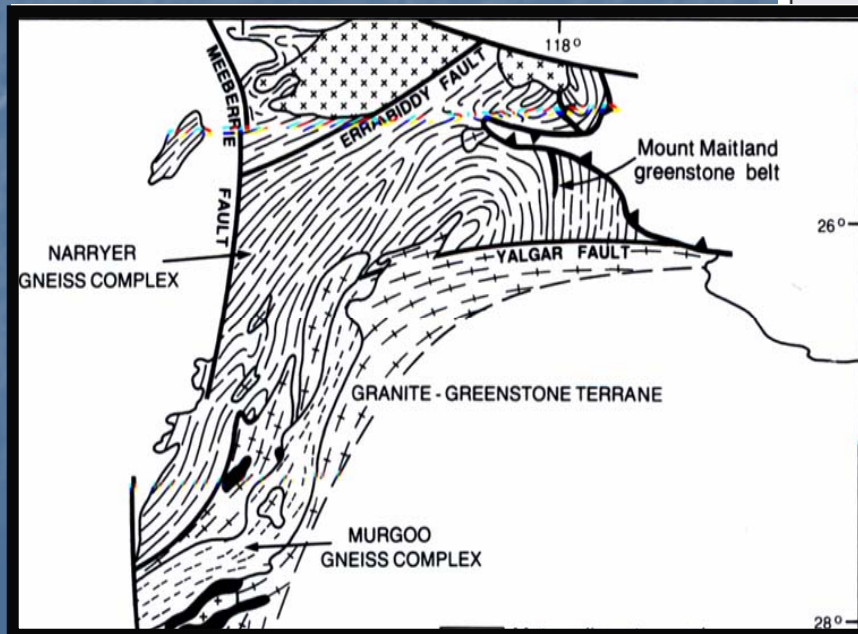
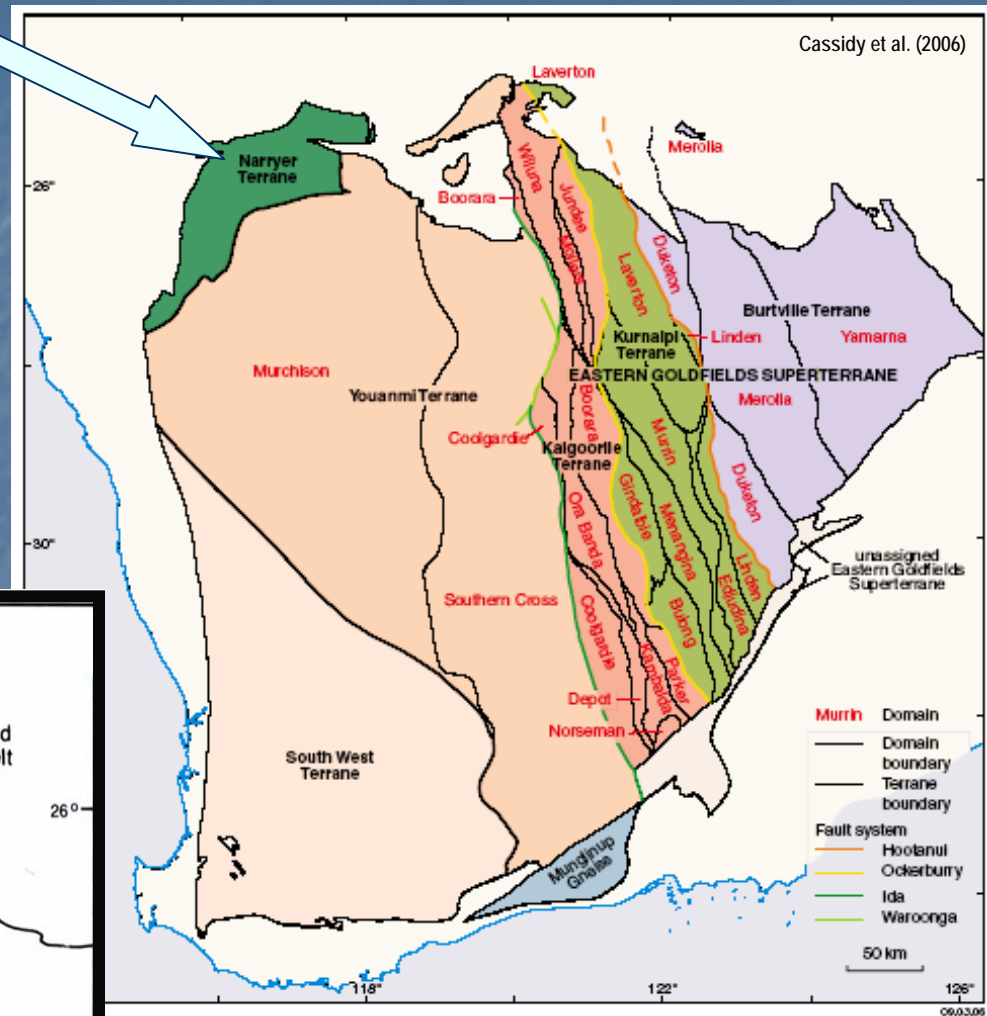
Lander Wyoming

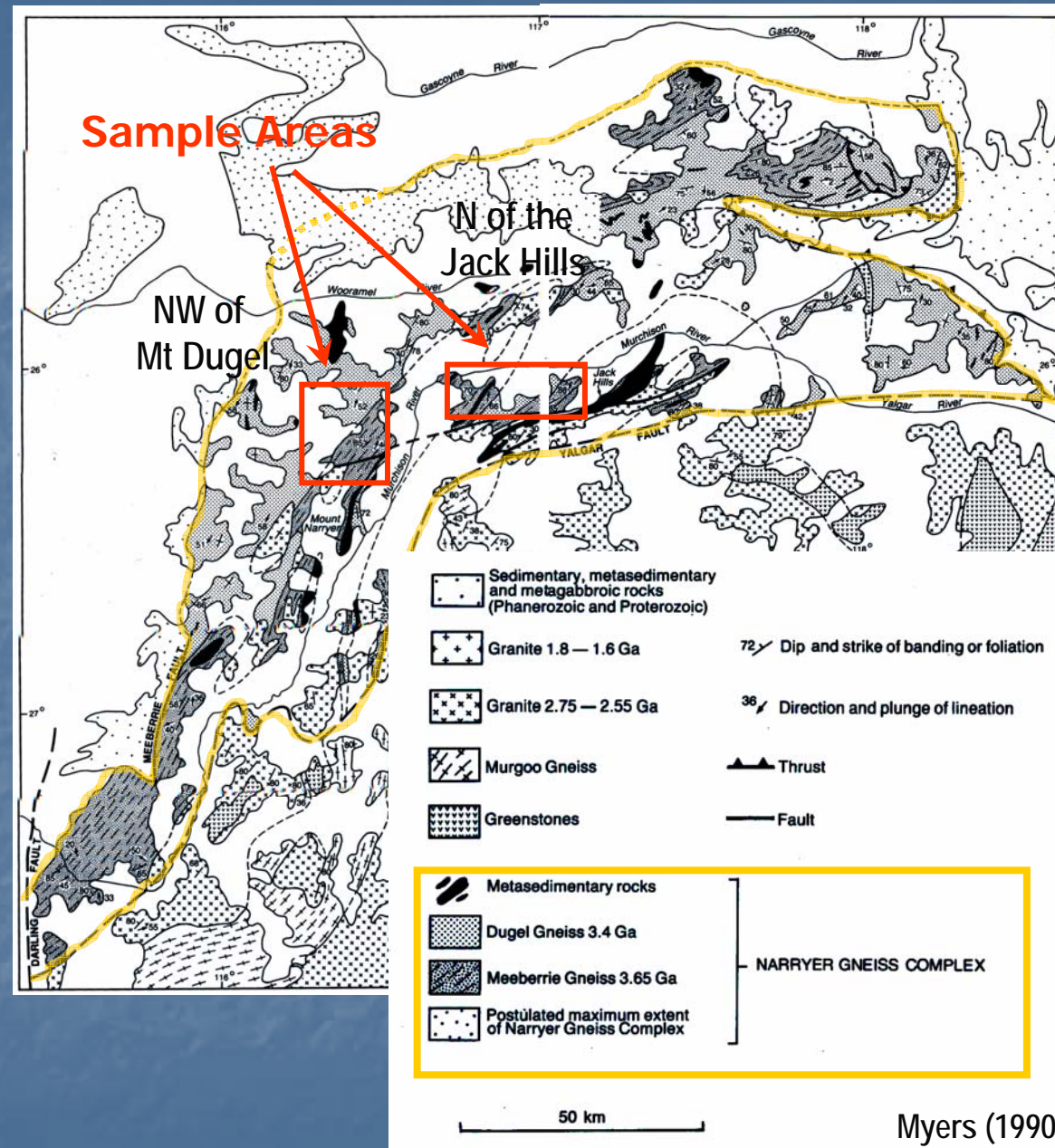
Synopsis

- Narryer Gneiss Complex (NGC) of Western Australia is one of largest intact blocks of early-middle Archean rocks (3.7 – 3.2 Ga) on Earth.
- New U-Pb zircon geochronology and whole rock geochemistry of 25 NGC orthogneisses suggests the terrane formed largely from episodic, bimodal anorthosite/leucogabbro – granodiorite/monzogranite (ALG) magmatism.
- TTG and dioritic magmatism is rare.
- ALG suites represent a newly-defined, distinctive magmatic association for the Archean, similar in some respects to Mesoproterozoic AMCG suites.
- Pre-3.2 Ga magmatism in the NGC occurred mainly in 4 pulses over 500 million years, each lasting ~25 to 100 million years.
- Formation of ALG magmatic association is not easily reconciled with convergent plate tectonic processes (subduction).
- Suggests that a major mechanism of mantle heat loss before 3.2 Ga was by episodic, but long-lived, within-plate magmatism in intra-continental rifts or at hot spots.

The Narryer Terrane

- Oldest known component of Archean Yilgarn craton of W.A.
- One of the largest intact blocks of >3.2Ga rocks on Earth
- Meta-anorthositic rocks and granitic gneisses as old as 3.7Ga
- Metasedimentary rocks with detrital zircons of Hadean age





Granite gneisses of Narryer Gneiss Complex

Mapped as two groups:

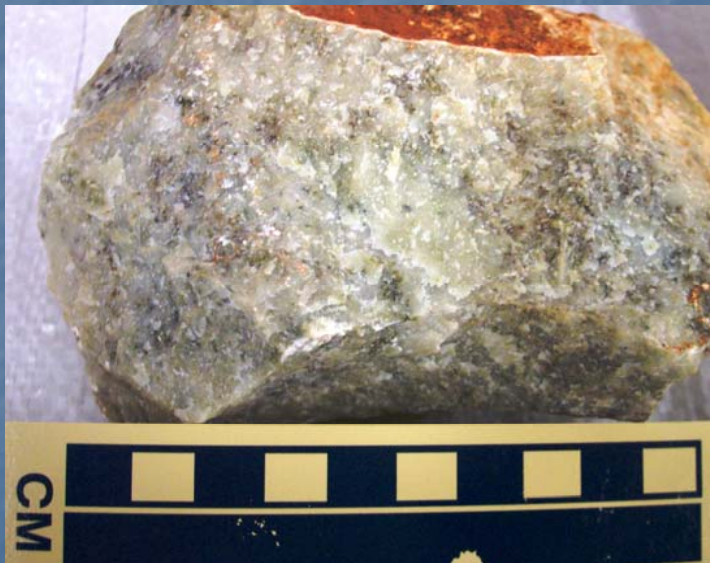
- Meeberrie Gneiss derived mainly from monzogranite, with minor tonalite/diorite
- Dugel Gneiss derived mainly from syenogranite and monzogranite – and intruding the Meeberrie Gneiss

Dugel gneiss contains inclusions of layered leucogabbro-anorthosite rocks called the Manfred Complex. All gneisses are intruded by voluminous late Archean granite sheets.

Meeberrie Gneiss, deformed porphyritic biotite granodiorite



Dugel Gneiss, even grained leucocratic granite

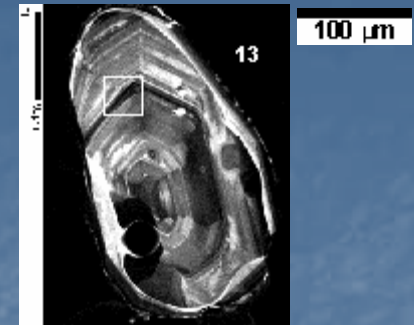
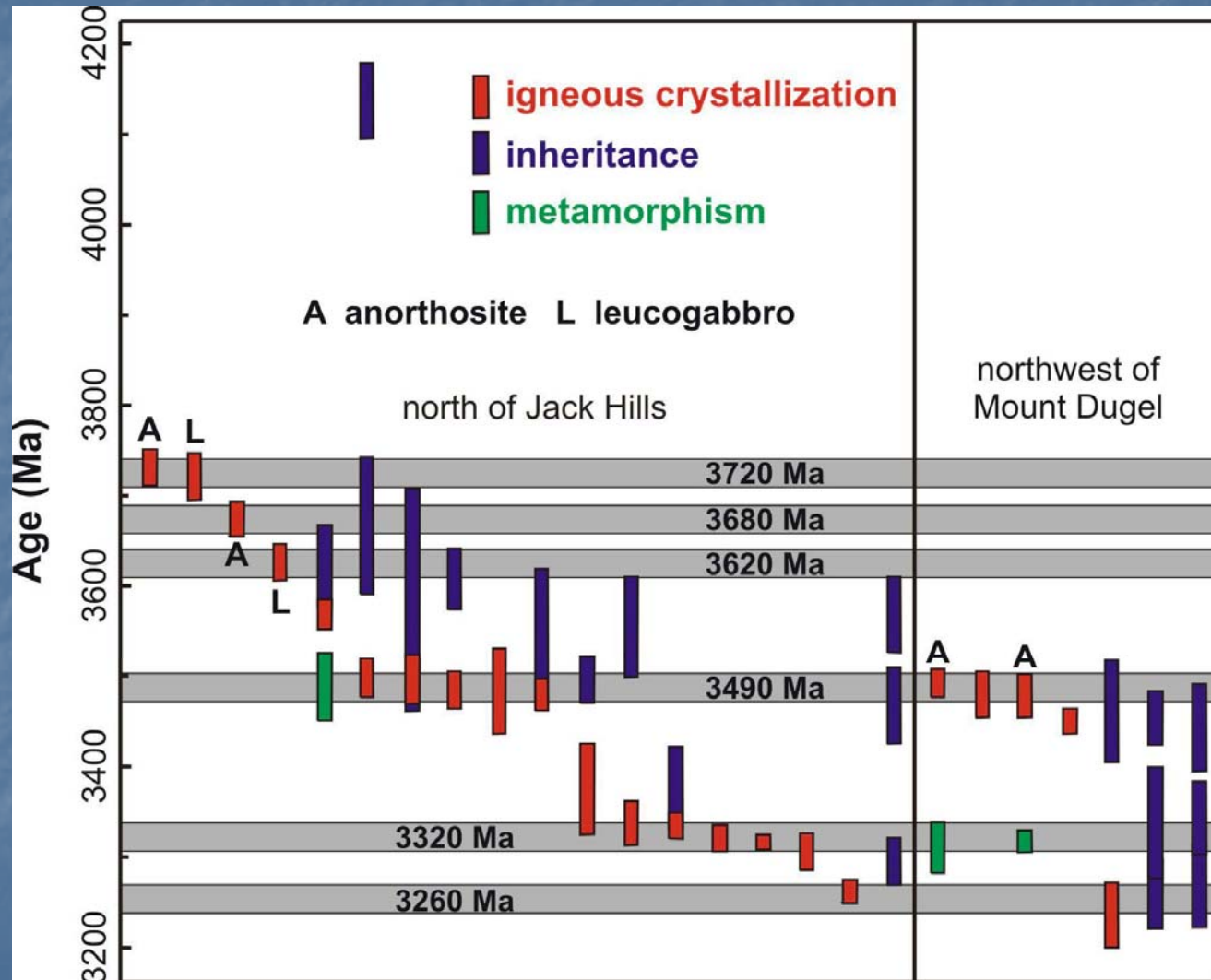


Anorthosite with recrystallized plagioclase, clinozoisite, epidote



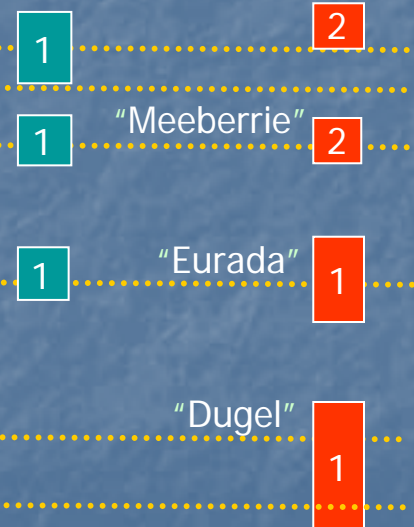
Leucogabbro with megacrystic (igneous) plagioclase

Laser ablation ICPMS U-Pb zircon geochronology of Narryer Gneiss Complex



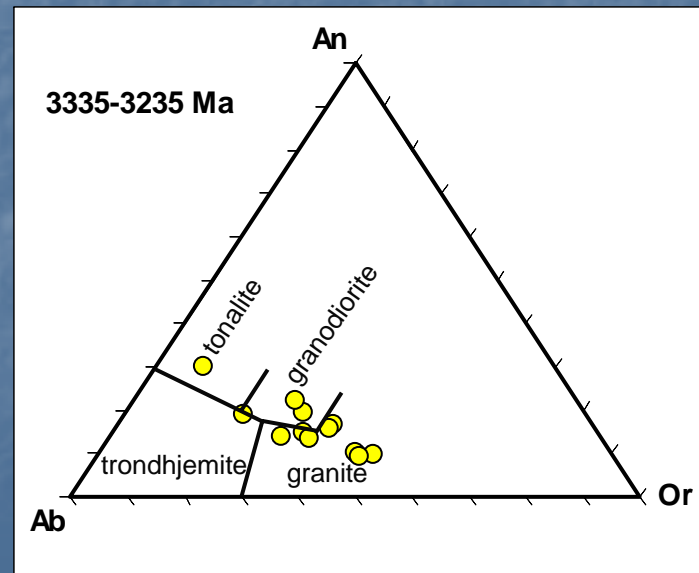
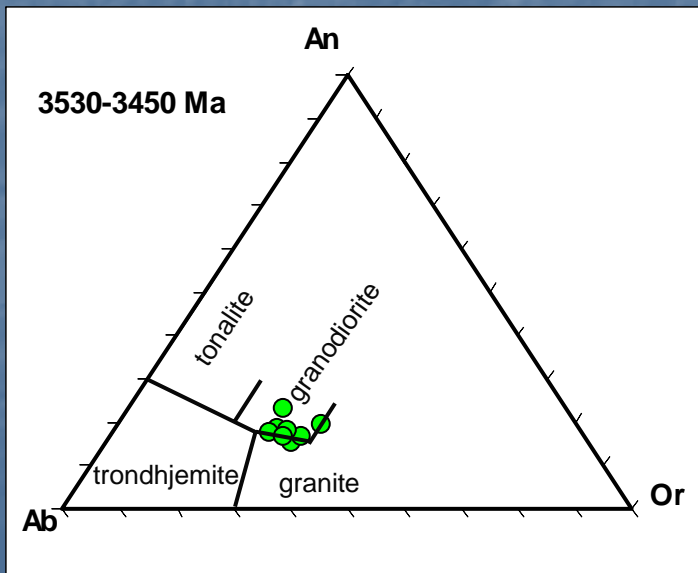
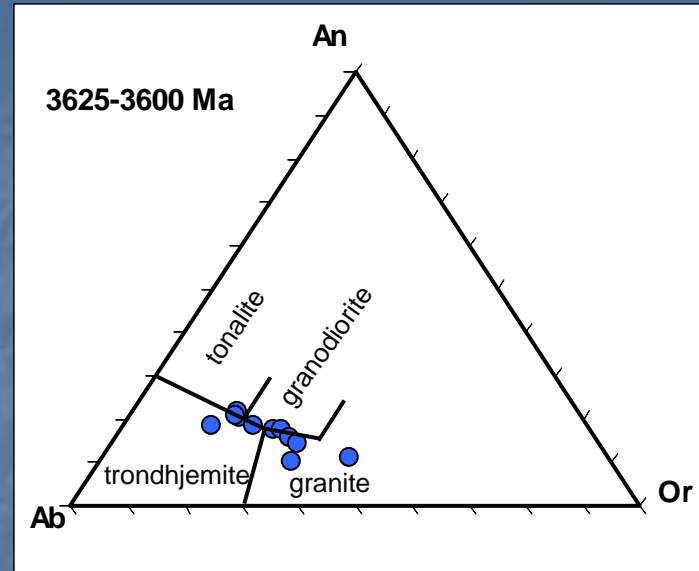
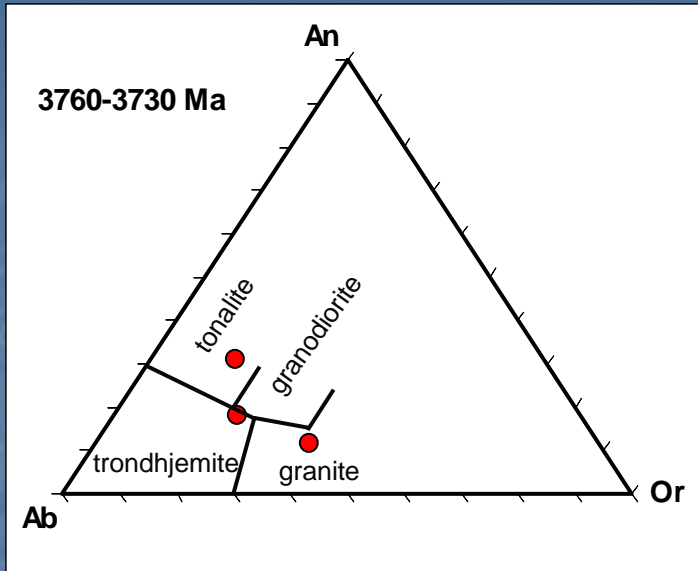
Summary of Major Magmatic Episodes

Anorthositic Granitic

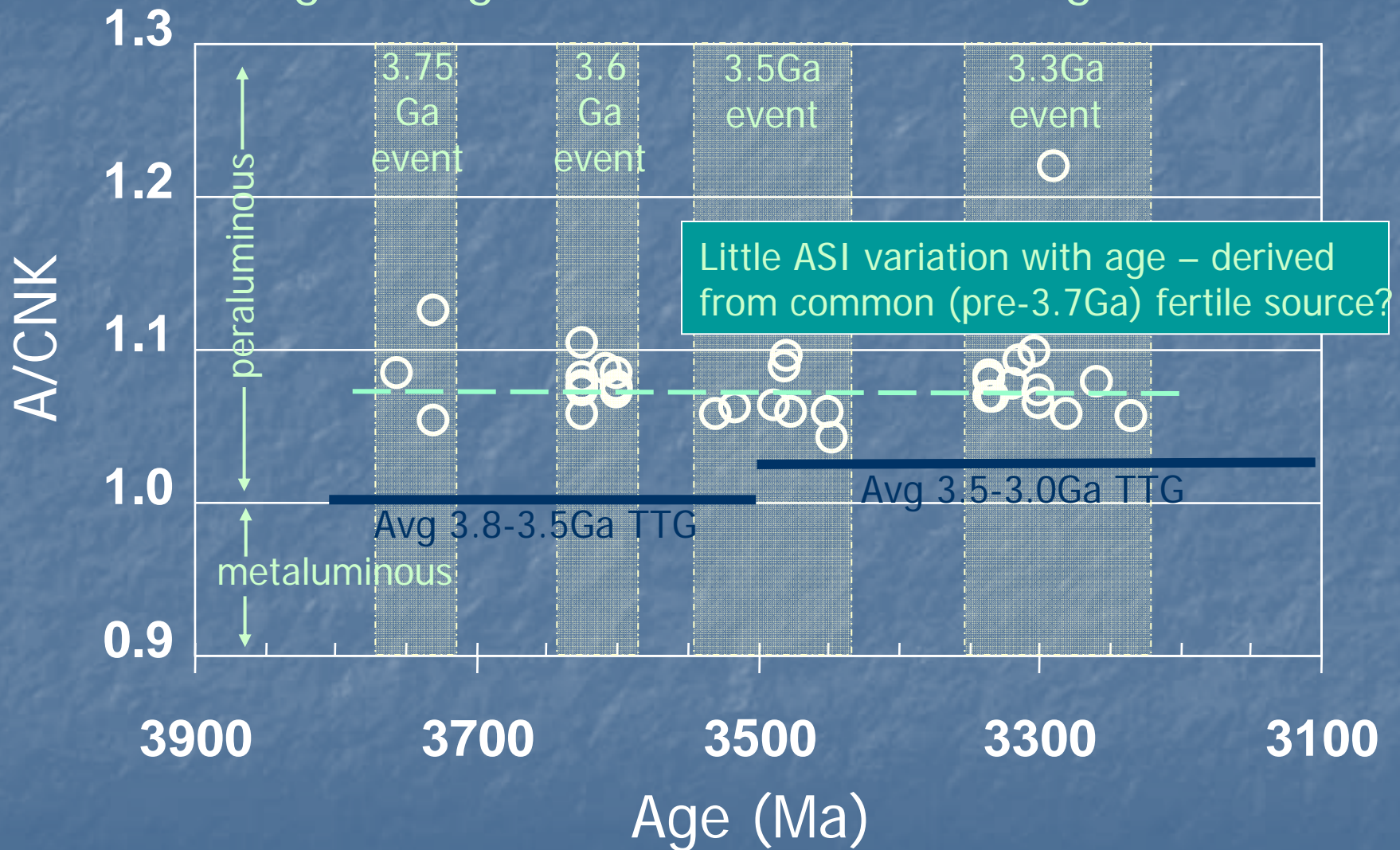


1 – This study
2 – Kinny & Nutman (1996);
Pidgeon & Wilde (1998)

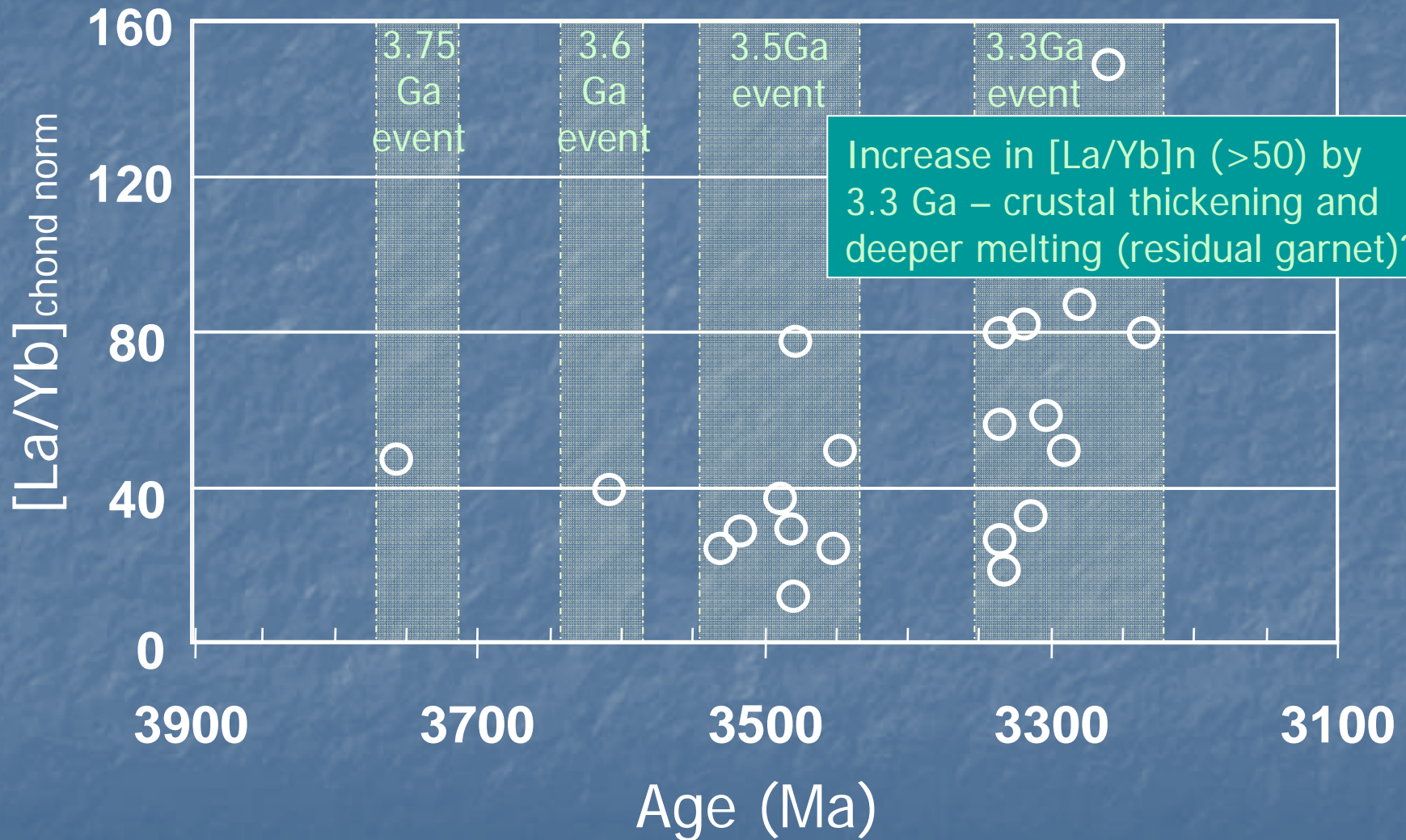
Compositions of granite gneisses of Narryer Gneiss Complex



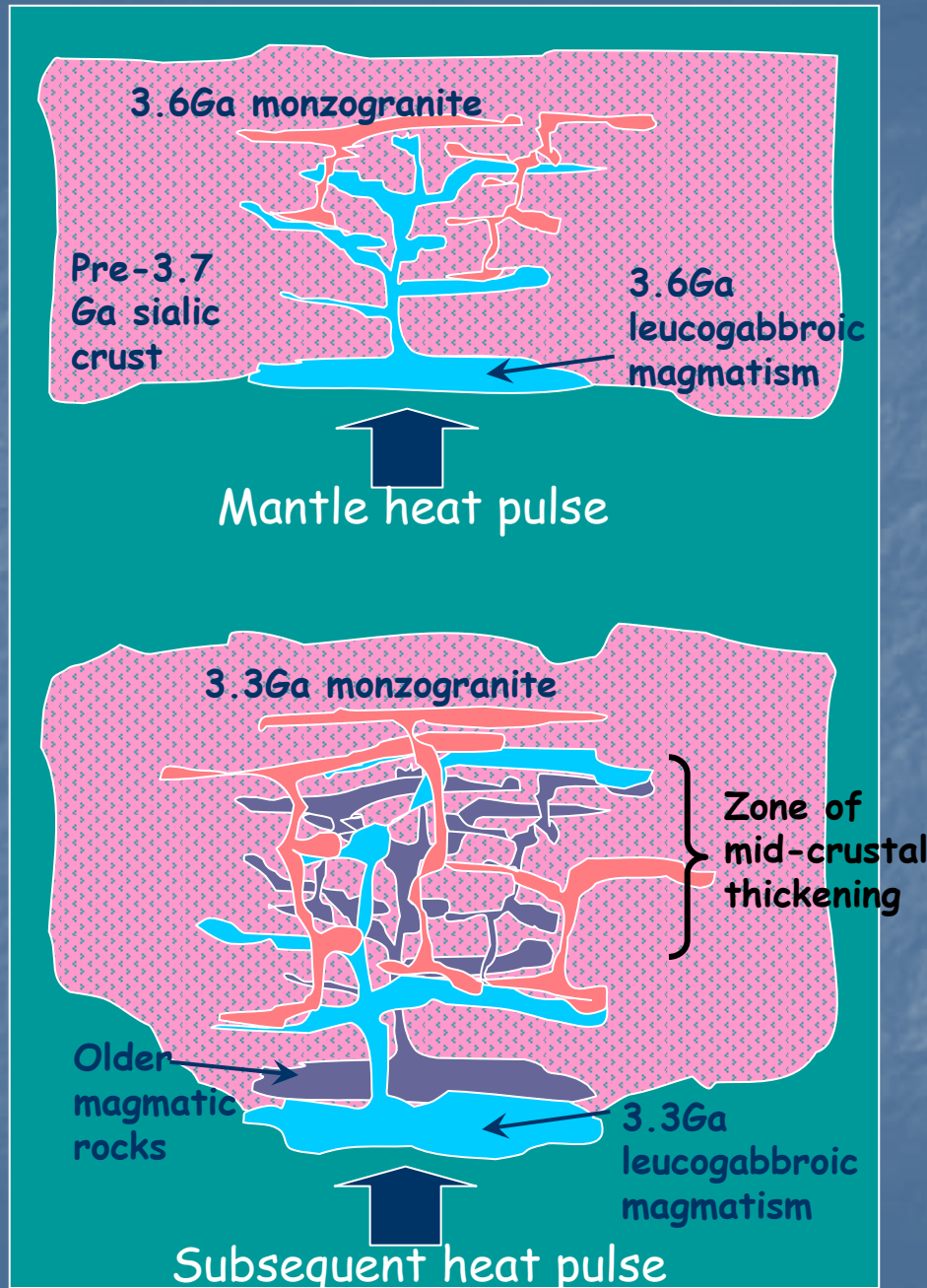
Alumina saturation index of Narryer Gneiss Complex granite gneisses as a function of age



REE fractionation in Narryer Gneiss Complex granite gneisses as a function of age



One Possible Geologic Model



3.6 Ga Magmatic Event

- mantle-derived leucogabbroic magma intruded at base of crust and within mid-crust
- magmatic thickening of crust by mid-crustal leucogabbro sheets
- monzogranite magmatism derived by intracrustal heating from injected leucogabbros

3.3 Ga Magmatic Event

- subsequent leucogabbroic magmatism
- further magmatic crustal thickening
- subsequent monzogranite magmatism derived from deeper parts of thicker crust