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Remarkable preservation: metamorphic processes in the 3.5 Ga North Pole Dome, Pilbara Craton, Australia

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Archean volcanic successions are widely known as greenstone belts because the majority have been affected by what most consider to be ‘regional’ greenschist facies metamorphism. However, detailed mapping, petrography, and thermobarometry of 3.49–3.46 Ga greenstones in the North Pole Dome has shown that typical greenschist facies assemblages form part of repeated downward-increasing temperature profiles preserved in volcanic packages 3–4 km thick that are bounded above and below by thick chert horizons [1,2]. The full range of mineral assemblages in packages varies from (kaolinite)–illite–quartz immediately beneath capping cherts (Fig. 1), through greenschist facies assemblages (chlorite–epidote–carbonate–white mica (mostly illite, but also minor paragonite)) in the bulk of the packages, to actinolite–chlorite-bearing rocks near the base [1,3]. Temperature estimates range from 150–250 °C near the top of the packages, to a maximum of ~400 °C near the base. These metamorphic assemblages are demonstrably early, as they are overprinted by an amphibolite facies (hornblende–plagioclase) thermal contact metamorphic aureole surrounding the 3.45 Ga North Pole Monzogranite that occupies the core of the dome. This supports previous models of seafloor metamorphism of this lowest part of the Warrawoona Group, which included local steam-heated acid–sulfate alteration associated with more widespread hydrothermal processes (Figure 1).

Figure 1: A) Outcrop of kaolinite–illite–quartz altered pillowed komatiitic basalt from immediately beneath the Dresser Formation. B) Cross-polarised thin section photomicrograph of A), showing pristine pyroxene spinifex texture despite complete alteration to kaolinite–illite–quartz.

Preservation of such ancient, low-grade assemblages is remarkable and results from two geological controls. 1) Metamorphism resulted from hydrothermal fluid circulation that was restricted to the upper part of volcanic packages, as the succession was being constructed. Drivers of fluid flow were emplacement of subvolcanic sills. Fluid circulation was bounded below by major chert horizons that acted as acquacludes to downward circulation [2]. Thick overlying cherts served to then isolate the packages from subsequent metamorphism associated with the deposition and hydrothermal alteration of the next package. 2) The volcanic succession was erupted as a volcanic plateau atop a developing thick lithospheric keel [4], which served to insulate the crust from mantle heat. Combined, these processes served to isolate and insulate early-formed metamorphic assemblages from further alteration over billions of years.

References:
[1] Terabayashi M et al. (2003) Precambr Res 127: 167-180.
[2] Van Kranendonk MJ (2006) Earth-Sci Reviews 74: 197-240.
[3] Poole G and Van Kranendonk MJ (2013) Abstract, 26th Int Applied Geochemists Symp, Rotorua, NZ.
[4] Smithies RH et al. (2005) Earth Planet. Sci. Lett. 238: 284-297.