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Diamonds from a New Witwatersrand-Like Gold Deposit Show Evidence of Archaean Subduction in the Slave Craton, Canada

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Earth's ancient tracts of continental crust – the cratons – produce 90% of Earth's gold and platinum and almost all its diamonds. One key to the long-term production and preservation of these mineral resources was the creation of thick, buoyant 'keels' of lithospheric mantle that underpin the crust. These cratonic keels represent Earth's major diamond-forming factories, however, the exact mechanisms and timing of their formation remain highly controversial. This is partly due to the scarcity of direct mantle samples from the Archaean, when cratonic keels began to form. Detrital diamonds hosted within Archaean-aged sediments represent the only undisputed direct samples of the Archaean mantle, serving as valuable geochemical windows into the processes that produced Archaean cratonic keels.

Here we report the recovery of 25 microdiamonds from the Tree River region of the Slave Craton. These are hosted within a >2.83 Ga gold-rich (grades up to 36.3 g/t) conglomerate, which bears striking similarities to the world-renowned Witwatersrand deposit, Kaapvaal Craton, South Africa. Both deposits are quartz-pebble conglomerates formed during the 2.9–2.8 Ga "golden window" and contain abundant carbon stringers and detrital pyrite, along with scarce detrital diamonds.

Carbon and nitrogen isotope values for diamonds from Tree River ($\delta^{13}C$ -19.5 to -0.3‰, $\delta^{15}N$ -1.7 to +14.5‰) exhibit far greater variation than those from the Wits ($\delta^{13}C$ -5.7 to -3.0‰, $\delta^{15}N$ -0.5 to +2.7‰). One stone represents the oldest strongly $\delta^{13}C$ depleted diamond (~-19.5‰) and contains inclusions of garnet, clinopyroxene, and magnesite, pointing to an eclogitic paragenesis. Such extreme stable isotope variation requires the input of surface-derived material into the diamond-forming fluid reservoir within the Archaean Slave cratonic keel. This requires subduction/imbrication of bio-altered oceanic crust/carbonates at 2.9 Ga, possibly to 3.5 Ga. Invoking such geodynamic regimes during the Archaean has far-reaching implications for our understanding of economic deposit formation in the Archean.