Trace-element fingerprints of chromites and sulfides from the Archean Nuggihalli greenstone belt, western Dharwar craton, India

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The Nuggihalli greenstone belt hosts discontinuous lens-shaped bodies of 3.1Ga plutonic ultramafic-mafic rocks (chromitite-bearing serpentinite and tremolite-chlorite-actinolite schist, pyroxenite, anorthosite, magnetite-bearing gabbro), that are conformably surrounded by a contemporaneous unit of metavolcanic schists (komatiite-komatiitic basalt), encompassed within the tonalite-trondhjemite-granodiorite suite of rocks. Trace-element compositions analyzed by laser ablation ICP-MS on unaltered chromites (Cr# [100Cr /(Cr+Al)] = 79-87, Mg# [100Mg /(Mg+Fe^{2+}) = 45-55) show enriched values for Ti (1766-3277 ppm), Mn (2037-2615 ppm), Zn (382-763 ppm), Co (197-257 ppm) and lower values of Ga (21-27 ppm), Ni (660-1202 ppm), V (475-682 ppm) and Sc (3.99-7.14 ppm) relative to MORB. In chromite/MORB multi-element plots the trace-element patterns of the unaltered chromites resemble Archean chromites from Ni-sulfide unmineralized komatiitic rocks. Compositionally zoned chromites have modified core (Cr# = 65-73, Mg# = 7-15, Fe^{3+}# [100Fe^{3+} /(Cr+Al+Fe^{3+})] = 5-12, Ga = 10-29 ppm, Ti = 839-1680 ppm, Zn = 7098-9188 ppm, Sc = 2-7 ppm, Mn = 1701-5554 ppm, Ni = 113-570 ppm, V = 538-893 ppm, Co = 520-866 ppm) with rims of ferritchromit and rare magnetite (Cr# = 72-99, Mg# = 2-32, Fe^{3+}# = 23-77, Ga = 1.5-43 ppm, Ti = 544-8929 ppm, Zn = 578-13039 ppm, Sc = 0.62-30.69 ppm, Mn = 1284-25176 ppm, Ni = 200-3584 ppm, V = 157-2837 ppm, Co = 112-2255 ppm). The altered chromites show inter-sample, intra-sample, and intra-grain heterogeneity in trace-element distribution owing to hydrothermal alteration. Minor sulfides represented by millerite and niccolite (~2 modal%, 20-40 μm) occur in the interstitial spaces within massive chromitites. Disseminations (5-8 modal%, 20-50 μm) of chalcopyrite, pyrite and Ni-Co bearing sulfides occur in magnetite in the interstices and as inclusions. The platinum group elements are below the detection limits of laser ablation ICP-MS for all the sulfide occurrences in the Nuggihalli greenstone belt.

A Mesoarchean Paleosol from eastern India—the second oldest paleosol on Earth

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The Keonjhar paleosol, in the southern part of the Singhbhum craton has long been identified [1] but its age has not previously been well constrained. The paleosol occurs between the Singhbhum Granite and supracrustal siliciclastics unconformably overlying the granite, along the western margin of the pluton. The paleosol is locally mined for pyrophyllite. Recently, the paleosol has been classified as a vertisol [2]. The Singhbhum Granite on which the paleosol has been developed has been dated at ca. 3.33 Ga (U-Pb zircon LA-ICPMS) [3]. Here we report detrital zircon U-Pb LA-ICPMS ages from overlying sandstones covering a wide geographic locality from Pal Lahara in the west to Mahagiri hills in the east. U-Pb detrital zircon ages from four samples and more than 120 concordant or near concordant analyses indicate that the youngest grains cluster between 3.0 and 3.3 Ga, and none of the zircons are younger than 3.0 Ga. Our data suggest that the depositional age of the sandstones is ca. 3.0 Ga and thus constrain the age of formation of the paleosol between 3.0 Ga and 3.3 Ga. The Keonjhar paleosol is therefore the second oldest known paleosol on Earth, after the Pilbara paleosol (ca. 3.4 Ga) [4] and provides an excellent opportunity to study the Earth's Mesoarchean atmosphere directly from the rock record.

[1] Saha (1994), *Geol. Soc. Ind. Mem.* **27, 341p**. [2] Bandopadhyay *et al*. (2010) *Precamb. Res.***177**, 277-290. [3] Tait *et al*. (2011), *Geol. Mag*., **148**, 340-347. [4] Johnson *et al*. (2009), Goldschmidt Conference Abstract, A601.

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