

## RESEARCH ARTICLE

# High authigenic Co enrichment in the non-euxinic buff-grey and black shale of the Chandarpur Group, Chhattisgarh Supergroup: Implication for the late Mesoproterozoic shallow marine redox condition

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## Abstract

Persistently low enrichment of conventional redox-proxy trace metals, i.e., V, Cr, Mo and U in Mesoproterozoic black shale records, has generally been interpreted as an oxygen-depleted surface environment. However, new evidence in this study contradicts this concept. We performed an integrated trace metals, major oxides and total organic carbon investigation on the late Mesoproterozoic black/buff-grey shale of the Chandarpur Group. The results revealed no significant enrichment of V, Cr, Mo and U, however, intermittent high enrichment of non-detrital Co, Fe and Mn. As the studied section is non-euxinic, sulphidic Co scavenging seems to be an unlikely mechanism for the Co enrichment. A significantly positive correlation between Co and Mn, and  $Co_{EF}$  covariation with Fe/Al, strongly suggests the co-precipitation of Co and Fe/Mn in a well-oxygenated environment. This intermittent oxygenation of the sediment-water interface would have promoted the re-dissolution loss of V, Cr, Mo and U from the sediments deposited under preceding anoxic conditions.

## 1 | INTRODUCTION

Trace metal records from iron formations (IF) and black shales have distinctly demonstrated two major shifts in the Proterozoic earth's ocean-atmosphere redox condition: (a) the great oxidation event (GOE) ~2.4 Ga (Bekker et al., 2004; Holland, 2006; Karhu & Holland, 1996; Large et al., 2014; Rouxel et al., 2005; Scott et al., 2008) and (b) the Neoproterozoic oxidation event (NOE) ~0.8 Ga (Sahoo et al., 2012, 2016; Scott et al., 2008). The redox history of the earth surface between these two events (1.8–0.8 Ga) is poorly constrained and therefore has been a priority research topic in the last few years (Ansari et al., 2020; Canfield et al., 2020; Chakraborty et al., 2020; Chen et al., 2020; Gilleaudeau et al., 2020; Planavsky et al., 2020; Wang et al., 2020). Geochemical modelling suggests that the atmospheric oxygen level during the GOE rose to 1%–10% of present atmospheric level (PAL) (Holland, 2006; Kump, 2008), but, during the Mesoproterozoic, persisted below 1% PAL (Cole et al., 2016; Gilleaudeau et al., 2016; Planavsky et al., 2020)

with some isolated evidence of transient rise around 1.4 and 1.1 Ga (Diamond et al., 2018; Gilleaudeau et al., 2016; Wang et al., 2020). However, these suggested transient rises in the Mesoproterozoic atmospheric oxygen are not reflected in the traditional RSTE (Cr, Mo and U) records probably due to a synchronous increase in their draw-down in the deep marine euxinic environment (Reinhard et al., 2013).

The study of Co, which shows opposite redox property to that of Cr, Mo and U [reduced Co (II) is water-soluble and oxidised Co (III) is water-insoluble], in the modern ocean, is also well developed (Hawco et al., 2018; Noble et al., 2017; Saito et al., 2004; Tagliabue et al., 2018). Recently, Swanner et al. (2014) applied this knowledge of the Co redox-chemistry from the modern ocean to the Co data from IF, pyrite and euxinic shale records of Archean-Palaeoproterozoic age and suggested that the dissolved Co reservoir in the pre-GOE Precambrian ocean was maximum, and decreased in the post-GOE period due to waning hydrothermal activity as well as increased euxinic burial of Co. A more extensive pyritic Co dataset published by Large et al. (2019) has demonstrated an upsurge in Co concentration