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On the article "Weathered potassic volcanic rocks as protoliths of the hematitic phyllites of the southern Serra do Espinhaço (MinasGerais)": a discussion

Alexandre Raphael Cabral[1,2*]
Francisco Robério de Abreu[3]

[1] Universidade Federal de Minas Gerais
Instituto de Geociências
Centro de Pesquisas Professor Manoel Teixeira da Costa
Belo Horizonte MG Brazil
CEP 31270-901

[2] Centro de Desenvolvimento da Tecnologia Nuclear
Belo Horizonte MG Brazil
CEP 31270-901

[3] Pesquisador Autônomo
Sustain Geologia
Rua Tereza Mota Valadares 503/502
Belo Horizonte MG Brazil
CEP 30575-160

* Corresponding author
arcab@ufmg.br

RESUMO
Chaves e Knauer (2020) apresentaram três novas análises químicas de rocha total de filito hematítico, uma rocha metamórfica singular da Serra do Espinhaço meridional. Com base em suas três amostras e uma seleção de outras três amostras da literatura, Chaves e Knauer propuseram que a singularidade geoquímica da rocha - ou seja, altos teores de K_2O, Al_2O_3 e Fe_2O_3, e depleção em SiO_2 - representaria intemperismo de basalto alcalino rico em feldspatoide. Esta contribuição é uma discussão de seus novos dados, cujos teores em elementos traços estão em desacordo com aqueles de um protólito vulcânico potássico, derivado do manto, para o filito hematítico. Suas razões Nb/Th de ~3 e razões La/Yb normalizadas por condrito de ~9–17, por exemplo, são típicas da crosta continental. Também apontamos aspectos que escaparam à atenção de Chaves e Knauer (2020), um dos quais é a ocorrência ubíqua de turmalina no filito hematítico.
Palavras-chaves: Filito hematítico, magmatismo alcalino, intemperismo, metamorfismo, Serra do Espinhaço.

ABSTRACT
Chaves and Knauer (2020) have presented three new whole-rock chemical analyses of phyllitic hematite, a unique metamorphic rock of the southern Serra do Espinhaço. Based on their three samples and a selection of other three samples from the literature, Chaves and Knauer have proposed that the geochemical uniqueness of the rock – *i.e.*, high contents of K_2O, Al_2O_3 and Fe_2O_3, and depletion in SiO_2 – would represent a weathered, feldspathoid-rich alkaline basalt. This contribution is a discussion of their new data, the trace-element contents of which are at odds with those of a potassic, mantle-derived volcanic protolith for the hematitic phyllite. Its Nb/Th ratios of ~3 and chondrite-normalised La/Yb ratios of ~9–17, for instance, are typical of the continental crust. We also point out aspects that escaped the attention of Chaves and Knauer (2020), one of which is the ubiquitous occurrence of tourmaline in the hematitic phyllite.
Keywords: Hematitic phyllite, alkaline magmatism, weathering, metamorphism, Serra do Espinhaço

1 INTRODUCTION

Chaves and Knauer (2020) have recently published an article that presents two unsharp transmitted-light photomicrographs and whole-rock chemical analyses for three samples of hematitic phyllite, a *sui generis* metamorphic rock of the southern Serra do Espinhaço. Based on their new data and an incomplete data compilation, Chaves and Knauer (2020) have concluded that the protolith of the hematitic phyllite would have been a mantle-derived, but weathered, feldspathoid-rich alkaline basalt. Here, we discuss their new data, the trace-element signature of which is inconsistent with an alkali-basalt protolith, even if affected by deep weathering. We further point out aspects that escaped the attention of Chaves and Knauer (2020).

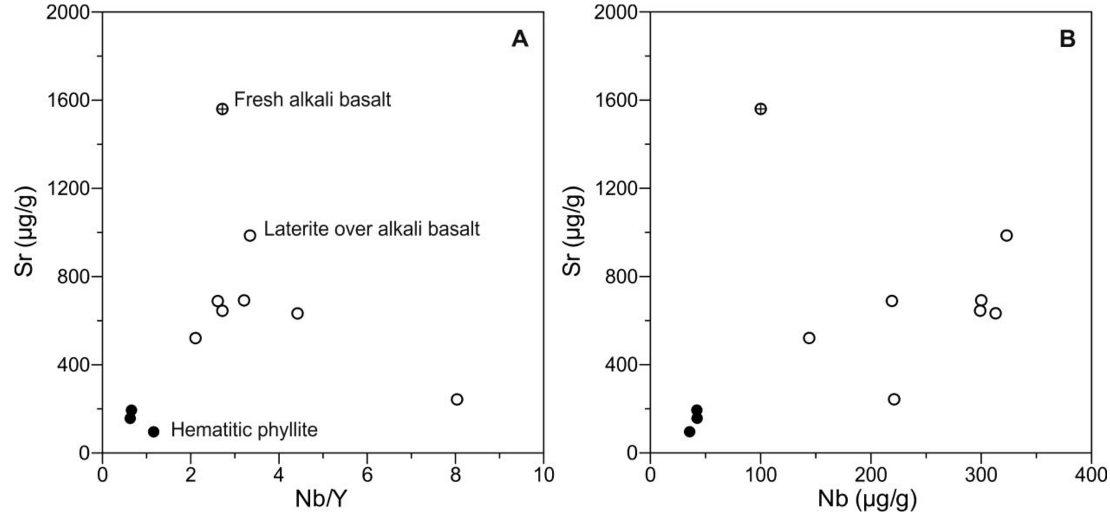

Figure 1
Plots of Nb/Y vs. Sr (A) and Nb vs. Sr (B) for the three samples of hematitic phyllite reported in Chaves and Knauer (2020), in comparison with fresh alkali basalt and its laterite profile (SANEMATZU *et al*. 2011).

2 DISCUSSION

One of the three samples reported in Chaves and Knauer (2020) plots within the alkaline-basalt field of the Nb/Y-vs.-Zr/TiO_2 diagram of Floyd and Winchester (1978). According to Chaves and Knauer (2020, p. 191), the aforementioned diagram would indicate that all their samples would have had chemical compositions similar to feldspathoid-rich alkaline basalt, which would have been modified by weathering before metamorphism. Weathering, however, is known to affect the mobility of Y, leading to Nb/Y ratios that span all compositions, from the andesite to the basanite–nephelinite fields of the Nb/Y-*vs.*-Zr/TiO_2 diagram of Floyd and Winchester (1978). This is the case of tholeiitic lavas that show all degrees of weathering from fresh olivine basalt to bauxite and Fe-oxide crust (HILL *et al*., 2000). Figure 1A further illustrates variable Nb/Y ratios from a lateritic profile over alkali basalt (SANEMATZU *et al*., 2011), which is typically enriched in Sr (BERGMAN, 1987). However, the purported samples of alkali-basalt-derived hematitic phyllite are not only depleted in Sr (Fig. 1A), but also in Nb (Fig. 1B). Despite depletion, Sr is considerably retained in lateritic profiles in a way that the alkali-basalt Sr signature can be recognised (SANEMATZU *et al*., 2011). Partial retention of Sr in lateritic profiles is due to the formation of aluminum-phosphate-sulfate (APS) minerals, such as goyazite (SANEMATZU *et al*., 2011). Even if extreme weathering erased the Sr signal, the characteristically elevated Nb contents of alkaline rocks would have been enhanced in weathered rocks (Fig. 1B; VALETON *et al*., 1997, SANEMATZU *et al*., 2011). Unless the weathering claimed by Chaves and Knauer (2020) was uniquely capable of effectively leaching Nb, the Nb contents of their samples, between about 36 and 42 µg/g Nb, rule out any weathered alkali-basalt protolith.

Two other lines of evidence for an alkaline volcanic protolith have been advanced by Chaves and Knauer (2020). First, the high contents of K_2O of their three samples, between 7.1 and 8.3%, would be comparable to the average K_2O contents of leucitite and lamproite (Table 2 of CHAVES; KNAUER, 2020). Apart from Al, Ti and Fe, the major elements would have been leached during weathering, but not K, the contents of which would have been preserved because of the absence of plants in the Precambrian. One wonders at such a preservation of K contents, whereas the Nb signature of a K-rich, mantle-derived rock would have been erased. As mentioned in the previous paragraph, the Nb signal should have been enhanced in weathering profiles over such rocks. Niobium and Th are so poorly mobile during oxidative weathering that Nb/Th ratios of lateritised products show little variation in relation to the fresh rock (Fig. 2). Most lateritised samples of alkali basalt of Figure 2 have Nb/Th ratios that are close to the fresh-rock Nb/Th ratio of ~8, which is typical of primitive-mantle-derived rocks (COLLERSON; KAMBER, 1999). In contrast, the samples reported by Chaves and Knauer (2020) have Nb/Th ratios of ~3 (Fig. 2), a value that is characteristic of the continental crust (COLLERSON; KAMBER, 1999; RUDNICK; GAO, 2003). Second, the chondrite-normalised pattern of the rare-earth elements (REE), as shown in Figure 4 of Chaves and Knauer (2020) as evidence for an alkaline-magma derivation of their samples, is misleading. Their samples bear resemblance to the chondrite-normalised pattern of the upper continental crust – UCC (Fig. 3), in agreement with their Nb/Th ratios. Potassic lavas have chondrite-normalised La/Yb ratios [$(La/Yb)_{cn}$] above 20, whereas the $(La/Yb)_{cn}$ values of Chaves and Knauer's samples are below 20, overlapping that of the UCC (Fig. 4).

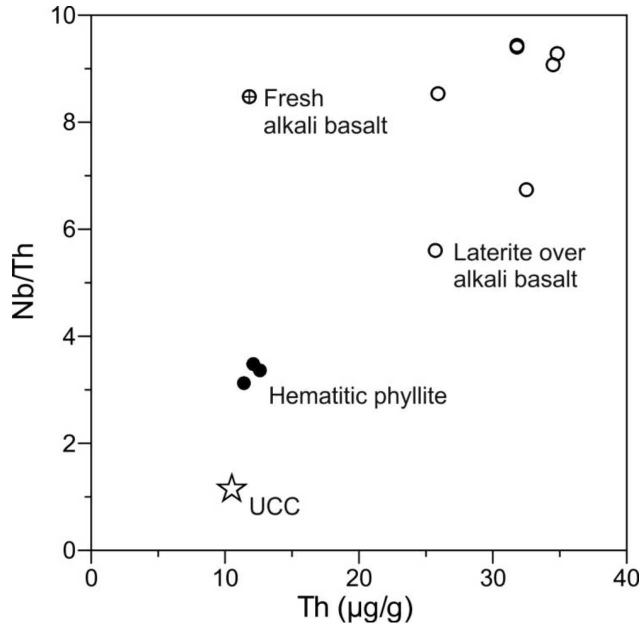

Figure 2
Plot of Th vs. Nb/Th for the three samples of hematitic phyllite reported in Chaves and Knauer (2020), in comparison with fresh alkali basalt and its laterite profile (SANEMATZU *et al*., 2011), and the upper continental crust – UCC (RUDNICK; GAO, 2003).

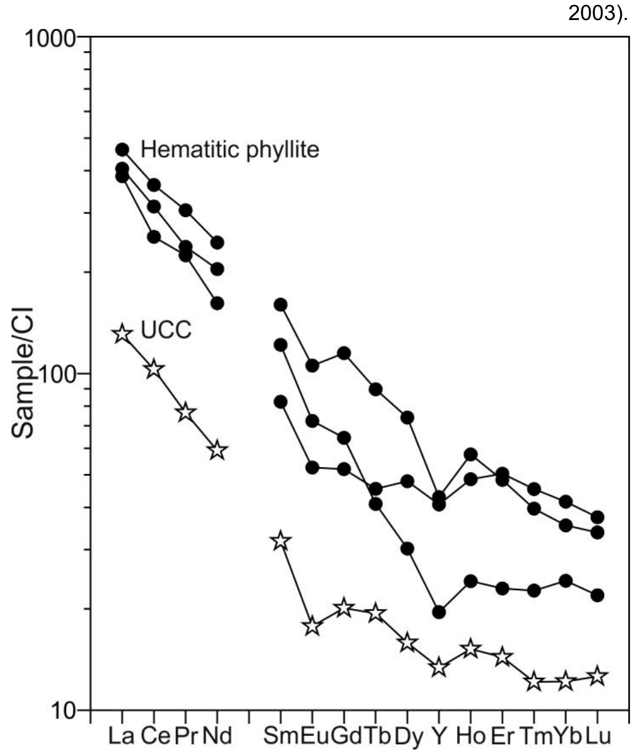

Figure 3
Chondrite-normalised plot of the rare-earth elements for the three samples of hematitic phyllite reported in Chaves and Knauer (2020), in comparison with the upper continental crust – UCC (RUDNICK; GAO 2003). Chondrite values are from McDonough and Sun (1995).

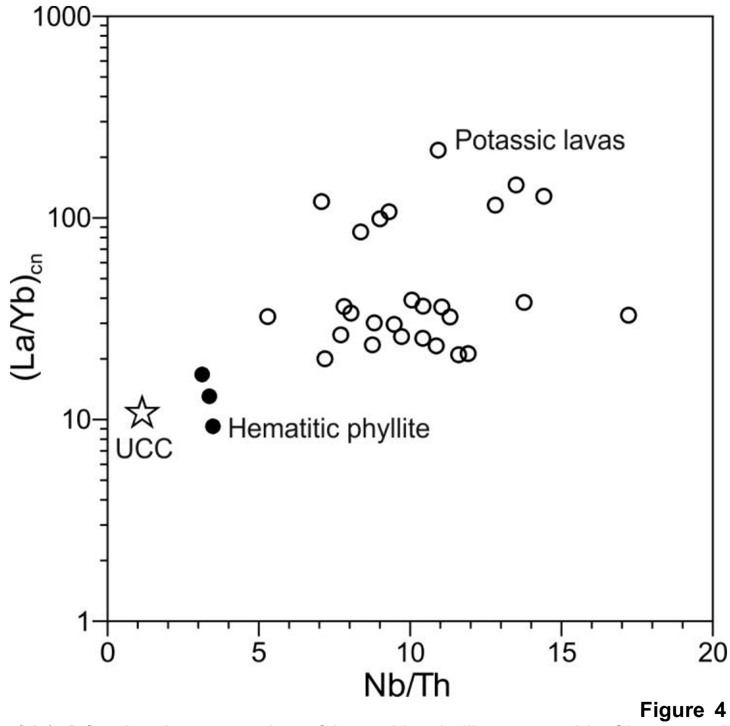

Figure 4
Plot of Nb/Th vs. chondrite-normalised La/Yb [$(La/Yn)_{cn}$] for the three samples of hematitic phyllite reported in Chaves and Knauer (2020), in comparison with potassic lavas (MITCHELL; BELL, 1976), and the upper continental crust – UCC (RUDNICK; GAO, 2003).

Two aspects that are relevant to the petrogenesis of hematitic phyllite escaped the attention of Chaves and Knauer (2020). First, only three of the seven samples of hematitic phyllite that are reported in Cabral *et al.* (2012) have been considered by Chaves and Knauer (2020) – see their Table 1 and Figures 4 and 5. Those four samples that were overlooked plot within the rhyolite–dacite field of the Nb/Y-vs.-Zr/Ti diagram of Pearce (1996) – see Figure 5b of Cabral *et al.* (2012). Taking into account all samples in the data set of Cabral *et al.* (2012), two protoliths for the hematitic phyllite can be distinguished: a basic rock and an acidic rock. Second, the widespread tourmalinisation in the southern Serra do Espinhaço, which is expressed in the hematitic phyllite as disseminations and pockets (CORRENS, 1932; DERBY, 1879, 1899, 1900a; MORAES; GUIMARÃES, 1931; CABRAL *et al.*, 2011). Derby (1900b) noted in the hematitic phyllite and enclosing clastic rocks "a new formation of monazite such as has been shown for tourmaline" (DERBY 1900b, p. 219). The hematitic-phyllite-hosted tourmaline, which occurs as disseminations and concentrations (in pockets), has chemical compositions that are characteristic of meta-evaporitic tourmaline of non-marine nature (Fig. 5). The presence of tourmaline in a matrix of fine-grained muscovite can thus be understood as B and K overprint on volcanic protoliths (CABRAL *et al.*, 2012). Therefore, the presence of high amounts of K_2O in the hematitic phyllite cannot be linked to potassic lavas, as interpreted by Chaves and Knauer (2020). Finally, Chaves and Knauer (2020) overlooked the work of Derby (1900a). He noted not only the peculiar presence of tourmaline in the hematitic phyllite, but also proposed that the phyllite "may result from the alteration of rocks, both massive and clastic, that had been decomposed and leached *in situ* (...)" (DERBY, 1900a, p. 213).

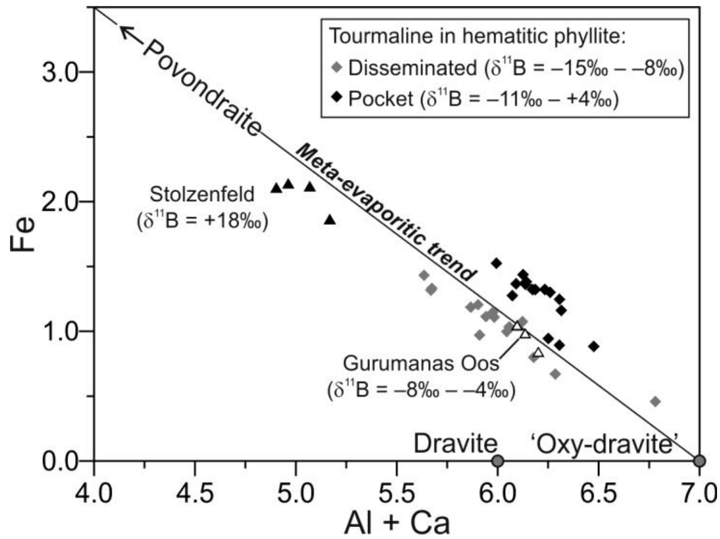

Figure 5

Plot of Al + Ca vs. Fe (HENRY *et al.*, 2008), in atoms per formula unit of tourmaline, for tourmaline in hematitic phyllite that is presented in Cabral *et al.* (2012). The povondraite–'oxy-dravite' join represents the meta-evaporitic trend (HENRY *et al.*, 2008), along which disseminated tourmaline and pocket tourmaline plot. The latter is offset to higher contents of Fe. Meta-evaporitic tourmaline from Namibia, Stolzenfeld and Gurumanas Oos (HENRY *et al.*, 2008), is shown for comparison. The boron isotopic compositions of the Namibian tourmaline and those hosted in the hematitic phyllite of the southern Serra do Espinhaço are from Palmer and Slack (1989), and Cabral *et al.* (2012), respectively. The predominance of negative $\delta^{11}B$ values in the hematitic-phyllite tourmaline and its meta-evaporitic composition are evidence for non-marine evaporitic B in the K-rich fluid overprint (CABRAL *et al.*, 2017).

3 CONCLUSIONS

The new data presented by Chaves and Knauer (2020) do not support a mantle-derived, K_2O-rich volcanic protolith for the rock known as hematitic phyllite in the southern Serra do Espinhaço.

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