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Hollandite group minerals in Lamproites from the Jharia Coalfield, Damodar Valley, India

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Introduction

Lamproites occur as minor intrusions within the Gondwana Coalfields of Damodar Valley, India. From previous studies it is apparent that these rocks exhibit considerable mineralogical diversity with respect to their silicate mineralogy. However, their oxide mineralogy, which is important for assessing the petrological affinities of the suite has not been well-characterized. Here we focus on the mineralogical studies of Hollandite Group minerals occurring in lamproites from the Moonidih Colliery, Jharia Coalfield.

Moonidih Potassic igneous rocks

The lamproites occurring at the Moonidih Colliery are porphyritic-tofine-grained. They consist primarily of: natrolite pseudomorphs after leucite; partially-serpentinized olivine (mostly occurring as phenocrysts and groundmass material), Ti-rich lath-shaped and poikilitic phlogopite and apatite phenocrysts; set in a groundmass containing amphibole and diopside, Mg-bearing ilmenite; diverse Mg-Al-poor, Zn-bearing spinels; rutile; and hollandite group minerals together with late-stage potassium feldspar, ferroan dolomite, , zircon, and quartz (Mitchell and Kent, 2010; Kaur et al., 2023)**.**

Hollandite group minerals in the Moonidih lamproites

The hollandite supergroup includes a number of manganese (IV) and titanium oxides, which are classified into two main groups depending on the dominant framework cation (M^{4+}): the coronadite group (M^{4+}= Mn); and the priderite group (M^{4+}=Ti). Priderite group minerals have been identified from the lamproite intrusions of Moonidih colliery in the Jharia basin. Although there have been reports of the sporadic occurrence of K-Ba titanites from the Damodar valley these lack reliable compositional data. The priderite group minerals described in this work are considered to represent primarily a transported assemblage of early-crystallizing oxides. Evidence for this conclusion is based on: the co-existence of adjacent anhedral priderite crystals with compositionally-different mantles of Ba-rich, K-poor hollandite on each grain; the absence of hollandite group minerals as euhedral phases included within apatite or phlogopite phenocryts or as a groundmass phase; and absence of overgrowths on late-stage ilmenite or rutile. Some priderite appears to have formed subsequent to the apatite phenocryts as it can be found partially-enclosing this mineral. Hence, the priderites are not genetically-unrelated xenocrysts. Typically, priderite forms anhedral-to-subhedral prismatic crystals with discontinuous or partial mantles of henrymeyerite or vanadian redledgeite. Overgrowths are interpreted to have formed prior to the incorporation of the crystals in their current host.

The K-Ba titanates recogniozed in the Moonidih lamproites represent three broad compositional ranges: priderite; redledgeite; and henrymeyerite. The priderites have K_2O (4.65-8.51 wt.%), BaO (2.56-12.99 wt.%), Cr_2O_3 (nd–1.14 wt.%), TiO_2 (68.14-75.9 wt.%), Fe_2O_3 (9.93-13.9 wt.%) and V_2O_3 (nd–2.19 wt.%) with no niobium. The vanadium redledgeites have K_2O (nd-0.57 wt.%), BaO (17.47-20.16 wt.%), Cr_2O_3 (8.24-10.43 wt.%) and V_2O_3 (1.9-5.06 wt.%), TiO_2 (61.08-65.46wt.%) and Fe_2O_3 (2.28-5.68wt.%). The henrymeyerites have K_2O (nd-1.89 wt.%), BaO (10.23-19.42 wt.%), Cr_2O_3 (nd-6.22 wt.%), V_2O_3 (nd-2.81 wt.%), TiO_2 (64.83-72.35wt.%) and Fe_2O_3 (6.74-13.36wt.%). On average priderites are enriched in K_2O and Fe_2O_3 and depleted in Cr_2O_3 and V_2O_3 with K_2O 5-6 wt.% and Fe_2O_3 >10 wt. and < 1 wt.% Cr_2O_3 and V_2O_3. Vanadium redledgeites and henrymeyerite have high BaO contents and are poor in K_2O in comparison to priderite.

The priderite group minerals from the Moonidih colliery plot in the priderite, redledgeite and henrymeyerite fields in a V-Fe-Cr ternary plot (Figure 1a). The ternary plot exhibits strong partitioning of Cr and considerable V in redledgeite (a later phase present on the rims of the priderite) whereas Fe is partitioned in the priderite (an earlier phase) and henrymeyerite. Compositions of hollandites from Moonidih lamproite are plotted in $Fe^{3+}/(Fe^{3+} + V)$ versus $K/(K + Ba)$ diagrams . The Jharia priderites overlap the hollandites of the West Kimberley Province lamproites, whereas Jharia henrymeyerite plot near the Prairie Creek Ba-Fe titanate (Figure 1b; Mitchell, 1995). The Jharia redledgeites fall close to hollandites of the Argyle lamproite (Figure 1b). Hollandites from New Elands, Star, Lace are enriched in V, relative to those from Sover North and Besterskraal (Figure 1b; Mitchell, 1995; Mitchell and Kent, 2010). These exhibit a wide range in $K/(K + Ba)$ and $Fe^{3+}/(Fe^{3+} + V)$ ratios that represent solid solution towards mannardite-potassian mannardite [(Ba,K)V_2Ti_6O16] and the (Ba,K)$Fe_2Ti_6O_{16}$ series (Mitchell 1995).

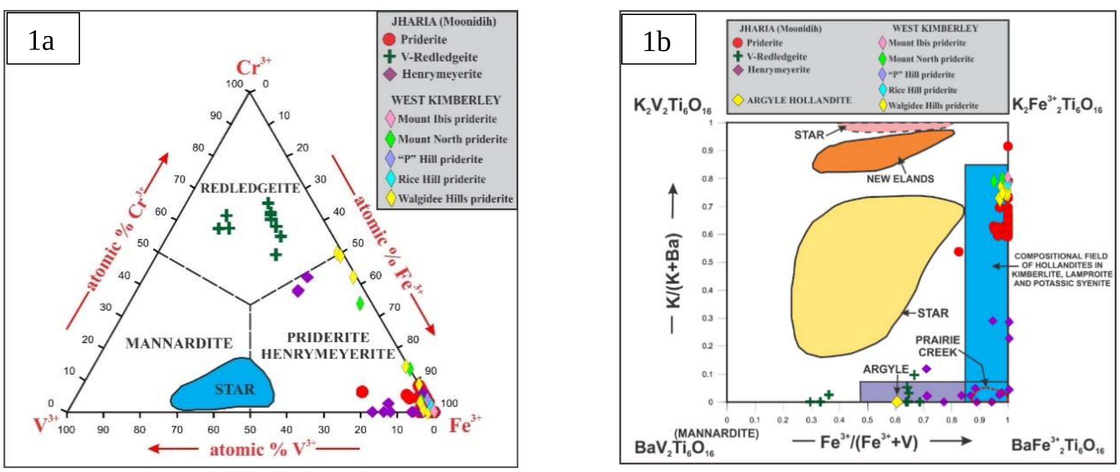

Figure 1: a. Compositions of K-Ba-Fe-Ti-oxide minerals from Moonidih lamproite expressed in the ternary system. Data for Star lamproite from Mitchell and Meyer (1989) and West Kimberley (Mitchell 1995; Jaques 2016); **b.** Compositions of hollandites from Moonidih lamproite plotted in $Fe^{3+}/(Fe^{3+} + V)$ versus $K/(K + Ba)$ plots. Compositional field of Star and New Elands K-Ba-V titanates is from Mitchell and Meyer 1989, Argyle hollandite from Jaques et al. (1989). Prairie Creek Ba-Fe titanate from Mitchell and Bergman (1991), Compositional field of hollandite in kimberlite, lamproite and potassic syenite from Mitchell (1995).

The hollandites from Moonidih lamproite have been plotted on the ternary system K_2O+BaO-TiO_2-Fe_2O_3+V_2O_3+Cr_2O_3 which has compositional fields for hollandites of Benfontein and Wesselton kimberlites, Kaapvaal lamproite, lamproites and Murun ultrapotassic syenites plotted on it (Figure 2a; Mitchell, 1995). To further resolve the character K_2O and BaO partitioning, the ternary plot BaO-(TiO_2+M_2O_3+Nb_2O_5)-K_2O has been used. Hollandite minerals from kimberlites, and Kaapvaal lamproites differ with respect to their BaO and K_2O contents (Figure 2b). The Jharia priderites are enriched in K_2O and form a distinct cluster overlapping with the West Kimberley Province lamproites whereas Henrymeyerite and redledgeite (enriched in BaO) form a distinct cluster, overlapping almost the Benfontein and Wesselton kimberlites, and Murun ultrapotassic syenites on the BaO-(TiO_2+M_2O_3+Nb_2O_5) edge of the ternary plot. There is no niobium reported from the Jharia hollandite minerals in contrast to the hollandites of the Kaapvaal lamproites which contain Nb_2O_3 up to 6.8 wt.% (Mitchell, 1995).

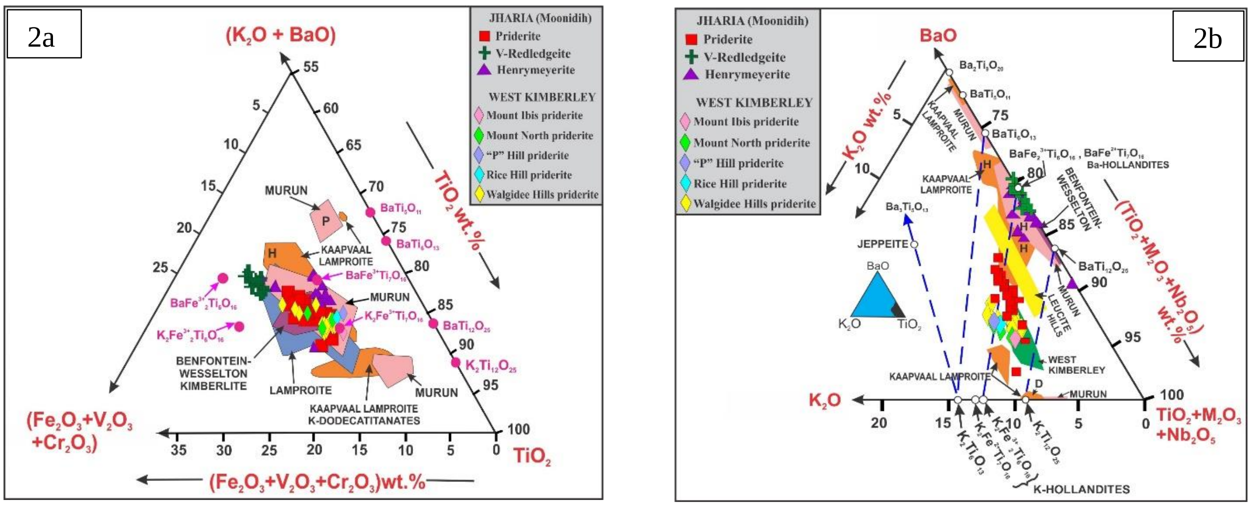

Figure 2: a. Composition of hollandites from Moonidih lamproite expressed in terms of ternary system K_2O+BaO-TiO_2-Fe_2O_3+V_2O_3+Cr_2O_3. Compositional fields for Benfontein and Wesselton kimberlites, Kaapvaal lamproite, lamproites and Murun ultrapotassic syenites from Mitchell (1995). P = Ba-pentatitanates, H = hollandites. **b.** Composition of hollandites from Moonidih lamproite expressed in terms of ternary system BaO-(TiO_2+M_2O_3+Nb_2O_5)-K_2O. Compositional fields for Benfontein and Wesselton kimberlites, Kaapvaal lamproite, lamproites and Murun ultrapotassic syenites from Mitchell (1995). M= Fe. Cr, V, and Al. H = hollandites; D = K-Dodecatitanate.

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