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How to make niobium highly mobile

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The High Field Strength Elements (HFSE) are generally considered immobile through geological processes this is especially true for Nb and Ta [1, 2]. The discovery of a new class of minerals from the alkaline Larvik Plutonic Complex in Norway has shown that Nb is highly mobile at natural weathering conditions, i.e. low temperatures and pressure [3]. The mineral peterandresenite ($Mn_4Nb_6O_{19}\cdot 14H_2O$) is the first mineral containing the hexaniobate ion. Hexaniobates are a subgroup of polyoxometalates, in which small highly charge cations bond with anions to form large ions or clusters. In geology the best-known examples are decavanadates or molybdates. The hexaniobate and hexatantalate ions are only stable under alkaline conditions, which explains why the only known hexaniobate minerals are from alkaline complexes. At acidic condition the typical carrier of Nb is $Nb_2O_5\cdot nH_2O$, however at pH > 8 the hexaniobate ion $[Nb_6O_{19}]^{8-}$ forms and the solubility of Nb increases with several orders of magnitude [4]. In a study of REE mobility as a function of pH it was shown that at elevated pH the generally accepted modes of REE mobility is not sufficient [5]. The discovery of the first hexaniobate minerals supports this and further highlights the need to understand speciation in order to explaining HFSE mobility. Furthermore, the pH of the hexaniobate fluid can determine what mineral structure forms e.g. pyrochlore or columbite [6, 7]. In addition, hexaniobate ions are known to be important intermediate phase in inorganic chemistry. Consequently, just because hexaniobate minerals are rare does not mean that the ion is not important as a transport mechanism, it just dissociates and forms other structures. As such, hexaniobates and other polyoxometalate minerals highlights that molecular species cannot be ignored when exploring HFSE mobility.

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