High pressure synthesis of new oxides and nitrides

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High pressure methods are important for synthesising new materials, and exploring changes of structure and property in dense matter. High pressure materials science will be introduced in the first lecture, and applications for materials chemistry will be illustrated with reference to new oxides and nitrides in lectures 2 and 3. High pressure often stabilises cations in unusual oxidation or coordination environments. Examples are perovskites with Mn^{2+} at A-sites, such as $MnVO_3$ [1], the double perovskite Mn_2FeReO_6 [2] and double double perovskites $MnRMnSbO_6$ and $CaMnFeReO_6$ with order of A and B site cations [3,4,5]. A remarkable variety of new iron oxides has recently been reported at high pressures, and we have explored the substitutional chemistry of Fe_4O_5. Complex magnetic orders are observed in $MnFe_3O_5$ [6] and $CoFe_3O_5$ [7], while $CaFe_3O_5$ (prepared at ambient pressure) shows electronic phase separation driven by trimeron formation [8]. A new quantum phenomenon, quantised weak ferromagnetism, has recently been discovered in the perovskite $YRuO_3$ based on the unusual Ru^{3+} state [9]. A high pressure method using sodium azide has recently been developed to synthesise nitrides in high oxidation states giving the iron(IV) nitride, Ca_4FeN_4 [10], an electron-localised Ni^{2+} nitride, Ca_2NiN_2 [11], and a rare example of a nitride perovskite, $LaReN_3$ 12]. The latter material can be decomposed to give novel reduction products $LaReN_{2.5}$ and layered $LaReN_2$ demonstrating topotactic reduction chemistry analogous to that of perovskite oxides like $LaNiO_3$ and $SrFeO_3$.

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