



Fig. S2b X-X pair distances in the  $ABX_3$  pPv phase. Seven different neighboring X-X distances are shown with the same colors used in Fig. S2a. In  $MgGeO_3$  pPv, both X2-X2\_h1 (dark blue) and X2-X2\_h2 (red) distances are the closest at 85-109 GPa, while X1-X2\_oh (yellow) is also as close as these pairs at ~80 GPa. The common feature among  $MgSiO_3$ ,  $MgGeO_3$ , and  $NaMgF_3$  pPv phases is that X2-X2\_h2 (red) is one of the closest pairs, while the closest X-X pair in  $CaIrO_3$  is X2-X2\_o (green). High-temperature Rietveld data are eliminated for clarity.