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SiO_2, P_2O_5, B_2O_3, and Al_2O_3 are all well-known network formers in oxide glasses, but the structure and properties of mixed Al_2O_3-B_2O_3-P_2O_5-SiO_2 glasses without the presence of network modifiers are poorly understood. Some of these glasses exhibit low values of elastic moduli and Poisson's ratio compared to traditional oxide glasses with network modifiers. This favors network densification when subjected to high local stress (e.g., indentation) at room temperature and it is therefore interesting to examine the structural response of these glasses to high pressure. In the present study, we investigate the influence of isostatic compression on the structure, density, and mechanical properties (hardness, crack resistance, and brittleness) of five Al_2O_3-B_2O_3-P_2O_5-SiO_2 glasses with varying Si/P ratio. The glasses are isostatically compressed at 1 GPa at the glass transition temperature, enabling permanent densification of large (~cm^2) sample specimens. In the as-prepared glasses, boron atoms become partially converted from the three- to the four-fold coordinated state when $[P_2O_5]>[Al_2O_3]$, with all Al_2O_3 maintained in tetrahedral groups. For $[P_2O_5]>([Al_2O_3]+[B_2O_3])$, boron is exclusively found in four-fold coordination, while the aluminum coordination number increases and all aluminum atoms are preferentially associates with phosphorus compared to silicon. Upon isostatic compression, the glasses permanently densify up to ~6%, leading to an increase in hardness and a change in the indentation cracking pattern. We discuss these pressure-induced changes in glass properties in relation to the structural changes quantified through Raman and ^{11}B, ^{27}Al, and ^{31}P NMR spectroscopy.