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Lithium aluminoborate glasses have been found to undergo large changes in their short-range structures under stress. This has important consequences for their mechanical behavior. To further understand structure-property relations in this glass family, we here study the effect of SiO_2 and P_2O_5 additions in lithium aluminoborate glasses. We find that the additions result in a more open network, but also with an increase in the average network rigidity. Consequently, we only observe a minor change in hardness, glass transition temperature, and Poisson's ratio. In lithium phosphoaluminoborate glasses, the cation-oxygen coordination numbers of both B and Al increase systemically upon hot compression, whereas the number of bridging oxygens around Q^n (P) decreases. We discuss these changes in relation to the mechanical properties. Overall the study provides insights into the complex structural interactions in mixed network former glasses and their impact on the mechanical properties.