Andesitic magmas are characteristic of subduction zone magmatism, but their origin remains controversial, with no consensus on even whether they are primary melts from the subarc mantle, or evolved by melt differentiation in the overlying crust. Here we present high-$^{3}$He/$^{4}$He (7.3 ± 0.3 R$_{a}$; n=25 samples) ratios from high-Ni olivines in order to demonstrate that basaltic to andesites magmas of the central Mexican Volcanic Belt originate from the sub-arc mantle despite the 50 km thick continental crust basement. We propose that silica supplied from the subducting slab is instrumental to the formation of these magmas. Through reaction with silicic fluids and melts from slab, sub-arc peridotite becomes interspersed with multiple segregations of silica-deficient and silica-excess olivine-free ‘reaction pyroxenites’. Ni-rich basaltic and dacitic initial melts from these pyroxenites, together with a subordinate amount of peridotite partial melts, mix to form hybrid high-Mg# arc andesites. Moderate fractional crystallization and recharge melt mixing in the upper crust then produces the lower-Mg# magmas. Our model accounts for the contrast between the arc-typical SiO$_{2}$ variability at a given Mg# and the strong correlations between major element oxides SiO$_{2}$, MgO and FeO which is not reproduced by mantle-crust mixing models. Moreover, it provides the option that viscous high-silica mantle magmas may preferentially form silicic plutons rather than erupt, and thus directly contribute to arc crustal growth. Ultimately, our results imply a strong turnover of slab and mantle materials in subduction zones with negligible, or low, dilution by materials from the overlying crust.