The building of the Andes results from the subduction of the oceanic Nazca plate underneath the South American continent. Variations of tectonics along the Andes correlate remarkably with the Nazca plate’s motions and morphology, suggesting that subduction dynamics exert a first-order control on this orogeny. However, the coupling between these plates and the role of the mantle remains unexplained. Three-dimensional numerical subduction models demonstrate that variations in slab thickness, arising from the Nazca plate’s age at trench, produces downgoing plate velocities and slab dips consistent with those observed. The age-dependent sinking of the slab in the mantle drives trench-ward traction at the base of the upper plate, causing it to thicken. Thus, older Nazca age below the Central Andes can explain the local thickening and the higher elevations. We demonstrate that it is the thickening of the South American plate that causes shear force gradients, similar to present, modifying trench migration in a way to produce a convex margin, matching that of the Bolivian orocline. Additionally, the varying forcing at the trench is expressed along stress belts propagating diagonally across the upper plate, explaining the widening of the Central Andes and the different tectonic styles in the Eastern and Western Cordilleras. The rise of Central Andes and orocline formation are directly related to the present-day Nazca plate age gradients, that only formed in the Eocene. This explains the enigmatic delay in the rise of the Andes, despite subduction ongoing since Mesozoic.