Fault creep at SAFOD is highly localized to two narrow zones of foliated gouge, the 2.6-m-wide Central Deforming Zone (CDZ) and the 1.6-m-wide Southwest Deforming Zone (SDZ). The CDZ takes up the majority of the creep, as evidenced by the more-pronounced well-casing deformation associated with it. Preliminary petrographic examination of recently obtained Phase 3 core samples indicates that both gouge zones record shear-enhanced metasomatic reactions between serpentinite tectonically entrained in the fault and adjacent sedimentary rocks. The gouges consist of porphyroclasts of serpentinite and sedimentary rock dispersed in a foliated matrix of the Mg-rich clay minerals saponite ± corrensite. Porphyroclasts of all types are variably altered to the same Mg-rich clays as the gouge matrix, and fractures lined with Mg-clays extend for a short distance (<1 m) into the sedimentary damage-zone rocks adjoining the gouge zones. Differences in texture and mineral composition between the CDZ and SDZ may be attributable to their different shearing rates. The SDZ core contains larger serpentinite porphyroclasts than the CDZ (Phase 3 Core Atlas, www.earthscope.org), and powder X-ray diffraction analysis of the gouge suggests a larger sedimentary component (e.g., quartz and feldspar contents) in the SDZ than in the CDZ. Veinlets of calcite up to 5 mm in length are preserved in the SDZ gouge matrix; these are more than an order of magnitude longer than the ≤200 µm long veinlets of anhydrite (?) found in the CDZ. The gouge-matrix clays in the CDZ are largely saponitic, with ~5-8 wt% Al₂O₃. In contrast, the SDZ is dominated by more corrensitic clays (~9-12 wt% Al₂O₃). Where age relations can be determined, saponitic clays are younger than corrensitic ones in the SDZ; for example, saponite concentrations are greatest adjacent to the late calcite veinlets. Smaller sizes and lower abundances of of both serpentinite and sedimentary porphyroclasts in the CDZ are consistent with a greater degree of shear-enhanced reaction to form the Mg-rich clays. The differences in clay-mineral compositions may reflect a change in physico-chemical conditions such as temperature or fluid chemistry, with clays in the more actively deforming CDZ adjusting more completely to the new conditions than those in the SDZ. Clay-mineral chemistry may prove useful for tracking variations in slip rate across the widths of the gouge zones.