Did differences in composition and strength of subducted sediment define the rupture of the great 1960 Chile earthquake?

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The great 1960 Chile subduction thrust earthquake was the largest, ever instrumentally recorded earthquake on Earth. The 1000 km long coseismic rupture is located between the overriding South American and the downgoing Nazca plates between 37˚S and 46.5˚S. Large amounts of sediment are subducted there at present, and have been subducted during the uppermost Tertiary and the Quaternary. Thus, sediment subduction may exert an important control on the mechanical behaviour of the seismogenic zone. We have studied compositions and geotechnical properties of modern clayey silts from this part the Southern Chile Trench. This is the dominant lithology, and a good analogue to sediments subducted in the past five million years. We found a strong southward decrease in feldspar and increase quartz suggesting a deep brittle-ductile transition at 37˚S, where the earthquake originated. Ring- and direct-shear experiments show a distinct southward drop in shear strength and friction coefficients. We infer that the rupture nucleated in an asperity zone defined by mechanically strong, feldspar-rich sediment. Shearing then catastrophically propagated southward into a very long, weak and narrow segment of the seismogenic zone, explaining the exceptionally large rupture observed. Our results suggest that detailed study of the input to other sediment-charged subduction zones, like Southwest Japan, the Aleutians, Cascadia or Sumatra, may help explain the exceptionally high intensity and extent of coseismic faulting there.