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Interactive comment on "Density structure and geometry of the Costa Rican subduction zone from 3-D gravity modeling and local earthquake data" *by* O. H. Lücke and I. G. Arroyo

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for the editor

The manuscript is well organized and the science discussion is well crafted. I would certainly recommend acceptance after the authors have responded to the discussion/reviews in progress and have modified their submission accordingly. Scientifically this study is in large part a refinement of far more generalized results in past investigations. The integrated earthquake seismic and gravity analysis of observations along a complex convergent margin significantly advances interpretation. The change in microseismicity corresponding with subduction of Cocos Ridge is a significant observation

previously not well defined. The discussion of serpentinization could be strengthened and perhaps there is a way to show the modification in slab configuration from previous work, especially from the study Arroyo published not too long ago. I do not have a marked up copy of the manuscript to send the authors but will be available to review the modified text prior to acceptance.

for discussion of the manuscript

In this study, integrating Arroyo's regional earthquake seismology and 3-D gravity of Costa Rica confirms its crustal structure including the unexpected configuration of Cocos Ridge subduction. It helps verify what was surprising and tentative in previous studies namely that Cocos Ridge subduction does not result in a flat slab. Along South America, flat slab subduction has been observed as volcanic ridges subduct, for instance in the wake of the migrating Juan Fernandez Ridge offshore Chile. It seems counterintuitive then that the buoyant Cocos Ridge slab first uplifts the upper plate and then steepens its path toward the mantle. The initial shallowing of the subduction zone offshore Cabo Blanco occurs where distal flanks of the Cocos Ridge subduct. Trench axial depth begins at ∼4800 m depth off Nicoya in the northwest, 3800 m at the beginning of the seamount province off Cabo Blanco, culminating in a shallow depth of ∼1500 m at the Cocos Ridge crest graben. Where the Ridge crustal thickness increases off Osa Peninsula, the slab first dips gently and then steepens. Presumably Osa Peninsula was uplifted by underthrusting of a buoyant Cocos Ridge. The buoyancy that uplifted the Osa Peninsula above sea level could also have contributed to the subduction erosion along central Costa Rica and perhaps to the contractile tectonics of the Fila de Costaena. Explaining shallow subduction that suddenly steepens is difficult and a corresponding change in seismic velocity could be constrained with a wide-angle seismic experiment. The increase in slab density in figure 4 is not explained as well as it might be. It would be helpful to see illustrated the wide-angle comparisons between gravity modeling results of the Sallares, Christesen and Stavenhagen 2D models and the experiments of Arroyo off Herradura/Quepos. Presumably these data guided the gravity model and discussion might strengthen the gravity modeling section. Serpentinization is probably a function of the bend radius, width of the area of normal faulting, and crustal thickness. Regarding lack of bend faulting across Cocos Ridge, as the Ridge enters the ocean basin “outer rise”region it breaks into major normal faults that have up to 1km of vertical displacement paralleling the ridge crest. So the Ridge extends along faults that are perpendicular to the trench. Since the thickened ridge crust increases depth to the mantle, the longer path may impede intrusion of seawater to mantle depth in addition to a reduced density of faults. A weakness of the slab detachment explanation is timing. The ridge may have arrived 3 myr ago and that would mean that 270 km are subucted. That accounts for the slab segment illustrated as a continuous slab in the preferred model (Figure 6). If the Talamanca uplift began 3 myr ago then a longer dense subducted slab is required for a piece of a slab to have detached and been replaced by lighter asthenosphere to provide the buoyant forces for uplift of the Talamanca mountains. I think the volcanic ash chronology from IODP drilling and other studies contain a possible subduction of a proto Cocos Ridge that might have been the detached segment but this is speculation.

Roland von Huene, 8.8.15

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