Earthquake potential in Costa Rica based on GNSS observations using three scenarios for the geometry of the Central Costa Rica block.

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1. Introduction

The Central Costa Rica Deformed Belt is a diffuse predominant northwest dextral-strike and conjugated northeast sinistral-strike faulting area, that represents the western border of the Panama Microplate (PM). This diffuse boundary crosses Central Costa Rica (CCR) from the Caribbean Coast, including the active Cordillera Volcanica Central, the Metropolitan Area (most dense population area in Costa Rica) and the Central Pacific coastline to intersects the Meso American Trench along the subduction of the Cocos Plate (CO).

2. GNSS Observation Data Set

We use 139 GNSS observation sites for inversion. The crustal deformation in Costa Rica is mainly arranged in three groups: 1). Northwestern Costa Rica is dominated by a northward deformation with rates up to 30 mm/yr, rotating and decreasing up to 20 mm/yr northwestward following the Central American Forearch. 2). Southeastern Costa Rica shows deformation to the North-eastward up to 40 mm/yr (opposite to northwestern Costa Rica). 3). Central Costa Rica is characterized by a diffuse deformation pattern oriented mainly to northward, with deformation rates up to a half of those observed in northwestern and southeastern Costa Rica.

3. Models and Method

We integrated interseismic geodetic data with seismicity records and inland faulting traces in other to evaluate earthquake potential in 3 kinematic models with different spatial geometries of the tectonic configuration around Central Costa Rica. Crustal deformation in Central Costa Rica and surroundings is modeled as result: i) kinematic effects of rigid block motions, ii) elastic deformation due to the interaction on subduction and inland tectonic interfaces and iii) internal strain of each tectonic block. We adopted the Markov Chain –Monte Carlo method in order to estimate the Euler poles of each tectonic block, slip deficit rates (SRD) on block interfaces, and internal strain of each block.

In order to evaluate the earthquake potential, we compare the seismic moment accumulation rate as $Mo=\mu\ A\ SDR$ (where μ is the rigidity, and A represent the locked area), with the seismic moment release rate based on a list of M > 6 earthquakes from 1798 for subducting earthquakes and from 1772 for inland earthquakes, obtained from previous studies.

4. Results and Discussion

In the Nicoya Peninsula (NP), we calculated a seismic moment deficit rate of 7.05 ±0.35 $\times 10^{18}$ J/yr, enough deficit to produce an M_w 8.2 earthquake every 318 ±16 years. In the Osa Peninsula (OP), we determined a seismic moment deficit rate of 27.4 ±2.5 $\times 10^{18}$ J/yr, this seismic moment deficit rate is comparable to an M_w 8.5 earthquake every 231 ±21 years. In inland boundaries of Central Costa Rica (CCR), we found up to a seismic moment accumulation rate of 33.4 ±3.0 $\times 10^{16}$ J/yr equivalent to an Mw 7.3 earthquake with a recurrence period of 299 ±27 years.

We assume that the seismic moment in a whole segment or patch is accumulated only as elastic strain and is released co-seismically. This assumption represents an upper limit of the earthquake potential since additional effects may contribute to the release of accumulated slips, such as the post-seismic deformation, plastic deformation, and the occurrence of slow slip events.

Figure Caption: Results of the Slip Deficit Rate (SDR) for subduction boundaries (A), inland boundaries (B) and historical seismicity. Figure shows inland boundaries of Model 1 (best model).