Active Deformation within the Cul-de-Sac Plain, Southern Haiti

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Regional Tectonic Settings

- Geological structures: subduction, vertical and thrust faults
- Relative motion of ~20 mm/yr
- Strain partitioning along faults in Haiti
- Historical earthquakes
- 2010 Haiti earthquake
Tectonic Interpretations

2 Different Scenarios:

- EPGF is a major tectonic feature of southern Haiti
- Quasi-vertical, left-lateral, active strike-slip
- from the westernmost tip of Haiti to the Enriquillo basin in the Dominican Republic.

- Slip on the EPGF stopped in the Late Miocene
- Near Pétionville EPGF imprint on the morphology becomes more subtle.
- south-dipping low-angle reverse fault underneath the high relief Massif de la Selle.

Dislocation theory establishes the relation between the earthquake and the coseismic surface displacement.

Crust is simulated as a \( \frac{1}{2} \) space with homogeneous elastic properties, the earthquake by \( N \) patches of slip on a fault plane.

The total displacement at the surface is the sum of the contribution of each patch to that displacement.

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U = [G]s
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Analytical expression have been derived for Green’s function in elastic \( \frac{1}{2} \) space: Okada, Y., Internal deformation due to shear and tensile faults in a half-space, Bull. Seismo. Soc. Amer., v. 82, 1018-1040, 1992.
- Which sites contribute to the strain accumulation on the fault plane?

- How do we solve for the orientation of the fault plane? Which fault line represented the best orientation?

- Can a vertical fault model explain the surface deformation?

- What is the effect of the locking depth on the model?

- What are the maximum strain rate accumulation on this structure?

- Can we add more complexities to the fault geometry?

- What are the uncertainties associated with these parameters?
Tested Geometries

Enriquillo Fault Section

Ganthier Fault

Shortening, locking depth = 5 km

Strike-slip, locking depth = 5 km

Distance (km)

Depth (km)

Elevation (m)

Velocity (mm/yr)

Enriquillo Fault Section

Ganthier Fault

Distance (km)
Strike-slip rate = 5 mm/yr
Dip-slip rate = 9 mm/yr
Fault Dip = 37
Locking Depth = 5 m
Fault Orientation : EW
- Magnitude 7 earthquake for both scenarios
- Strike-slip vs Dip-slip motion on faults
- Vertical vs Reverse faults
- Peak Ground Acceleration (PGA) has doubled in scenario 2 in Port-au-Prince area

Implications

- New interpretation of the regional tectonic settings
- Seismic hazards on populated cities such as Port-au-Prince is more important than expected
- Associated Peak ground motion has doubled in case of new scenario
- Important economic impact on the construction sector
Conclusions

- The shortening and the strike-slip components observed in the GPS data are being accommodated together by a south-dipping fault that overthrusts the Massif de la Selle onto the Cul-de-Sac basin.

- The resolution of the GPS data does not allow us to determine whether the deformation is accommodated by one or several faults.

- This thrusting, associated with a smaller component of strike-slip motion, explains the uplift of the Massif de la Selle and the formation of fault-propagation folds along the southern edge of the basin.

- The seismic hazard associated with this series of fault-propagation folds is as important as the threat posed by the Enriquillo Fault system.
Future Works

- Add more GPS sites in the study area
- Improve the uncertainties associated with the results
- Tested more models with more complex geometries
- Building new seismic hazards map for the region