Reconstructing the Northern Gulf of California-Salton Trough Oblique Rift

Scott Bennett 1
Mike Oskin 1
Rebecca Dorsey 2
Michael Darin 2
1 - University of California, Davis
2 - University of Oregon

Paper 3 - 8
GSA Cordilleran Section Meeting
Queretaro, Mexico
April 29, 2012

UCDAVIS
DEPARTMENT OF GEOLOGY
**GOALS**
- MARGINS integrative/synthesis activity
- Summarize current state of knowledge for MARGINS focus site
- Highlight recent advances in understanding in 4-D strain evolution
- Highlight unresolved controversies
- Visual tool for Earth Science educators

**METHODS**
- GIS-based
- 0 - 2 Ma (every 1 myr)
- 2 - 16 Ma (every 2 myr)

See Skinner et al. poster for Southern Gulf Reconstruction
Paper 10 - 1, Booth # 38 (This Afternoon)
DATA CONSTRAINTS

- Location of major shear zones and extensional basins
- Plate boundary studies
  - e.g. Atwater & Stock (1998), DeMets (1995)
- Geodetic studies
  - e.g. Plattner et al. (2007)
- Cross-Gulf tie points
  - e.g. [T] Oskin et al. (2001)
  - [F] Bryant (1986) and Gastil & Krummenacher (1977)
  - [P] Poway conglomerate outcrops in NW Sonora and SoCal
- Since ~6.1 Ma, >90% of PAC-NAM motion in GOC
  - Similar to modern-day GPS budget
- Detailed geologic studies
  - e.g. Bennett (2009), Seiler et al. (2010), many others
- Westward Migration of deformation
  - e.g. Aragon-Arreola & Martin-Barajas (2007), Bennett et al. (submitted, GSABull)
Previous Reconstructions

McQuarrie & Wernicke (2005)
GIS Reconstruction Tool

“Tectonic Reconstruct” by Richard Nava (USGS)

GIS v10

Install Add-In File

Excellent Reference Manual

Tectonic Reconstruct for ArcGIS 10 - v1.1

By rnavasnz_12

(0 rating)

Description

Tectonic Reconstruct provides a set of tools for the sequential reconstruction of tectonic features. Polygon or polyline type geometries, populated with rates of movement and directions, are continuously displaced from their present location for different points in time (time slices). Once reconstructed, displacement parameters for each feature in each time-slice may be modified inside an editing environment designed specifically for the recalculation of displacement values through map interaction.

The zip file includes:

- Add-In file for installation
- Reference manual
- Source code

Access and Use Constraints

Download Related Link

By clicking download you are acknowledging that you have read and agreed to the license:

Public Domain
GIS Reconstruction Tool

“Tectonic Reconstruct” v1.1

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>65.26</td>
<td>70</td>
<td>59.36</td>
<td>70</td>
<td>51.14</td>
<td>127</td>
<td>49.14</td>
<td>127</td>
<td>40.69</td>
<td>70</td>
<td></td>
</tr>
<tr>
<td>49.04</td>
<td>70</td>
<td>46.3</td>
<td>70</td>
<td>76.15</td>
<td>127</td>
<td>59.24</td>
<td>127</td>
<td>51.29</td>
<td>70</td>
<td></td>
</tr>
<tr>
<td>42.60</td>
<td>70</td>
<td>63.05</td>
<td>70</td>
<td>71.87</td>
<td>127</td>
<td>50.07</td>
<td>127</td>
<td>53.72</td>
<td>70</td>
<td></td>
</tr>
<tr>
<td>44.86</td>
<td>70</td>
<td>41.72</td>
<td>70</td>
<td>44.54</td>
<td>127</td>
<td>68.8</td>
<td>127</td>
<td>54.15</td>
<td>70</td>
<td></td>
</tr>
<tr>
<td>62.60</td>
<td>70</td>
<td>43.76</td>
<td>70</td>
<td>69.73</td>
<td>127</td>
<td>33.66</td>
<td>127</td>
<td>46.74</td>
<td>70</td>
<td></td>
</tr>
</tbody>
</table>

Input data frame:
Master layer:
Time slice units: Ma
Time slices: 1, 2, 4, 6
Slice prefix: time_slice
First displacement fields:
Rate prefix: A_RATE
Azimuth prefix: A_AZIM
Second displacement fields:
Rate prefix: B_RATE
Azimuth prefix: B_AZIM
Inherit layer symbology

CONSTRUCT RECONSTRUCT
GIS Reconstruction Tool

“Tectonic Reconstruct” v1.1

Block Rotation Coming Soon!

\[
\Delta t = \text{slice} - \text{prev slice} = 12 - 6 = 6 \text{ Ma}
\]
\[
r = 50.38 \text{ mm/yr}
\]
\[
M_a = 1,000,000 \text{ a}
\]
\[
d = (\Delta t \cdot M_a \cdot r) / 1,000
\]
\[
d = (6 \times 1,000,000 \times 50.38) / 1,000 = 30,228 \text{ m}
\]
Present-Day Geology
Present-Day Geology

BAJA-NAM Strain Budget = 46 mm/yr
[PAC-NAM = ~51 mm/yr]
Present-Day Geology

BAJA-NAM Strain Budget = 46 mm/yr
[PAC-NAM = ~51 mm/yr]
SLIP RATES

SALTON TROUGH
- Southern San Andreas: 14 mm/yr (Behr et al., 2010)
- San Jacinto-Superstition: 20 mm/yr (Janecke et al., 2011)
- San Felipe: 4 mm/yr (Janecke et al., 2011)
- Elsinore: 3 mm/yr (Dorsey et al., 2011)
- Offshore: 5 mm/yr

NORTHERN GULF
- Cerro Prieto: 36 mm/yr (Plattner et al., 2007)
- Laguna Salada: 5 mm/yr (Dixon et al., 2000)
- San Miguel-Vallecitos: 1 mm/yr (Dixon et al., 2000)
- Agua Blanca: 4 mm/yr

Approx. Shoreline
2 Ma

1 - 2 Ma SLIP RATES

SALTON TROUGH
- SAF-Sand Hills-Algodon: 37 mm/yr (Behr et al., 2010)
- W. Salton Detachment: 4 mm/yr (Shirvell et al., 2009)
- Offshore: 5 mm/yr

NORTHERN GULF
- Altar: 35 mm/yr (Pacheco et al., 2006)
- Laguna Salada: 7 mm/yr
- Agua Blanca: 4 mm/yr (Dixon et al., 2000)
2 - 4 Ma SLIP RATES

SALTON TROUGH
- SAF-Sand Hills-Algodon: 37 mm/yr (Behr et al., 2010)
- W. Salton Detachment: 4 mm/yr (Shirvell et al., 2009)
- Offshore: 5 mm/yr

NORTHERN GULF
- Altar-Amado-De Mar: 42 mm/yr (Pacheco et al., 2006)
- Agua Blanca: 4 mm/yr (Dixon et al., 2000)
SLIP RATES

6 Ma

4 - 6 Ma

SALTON TROUGH
- SAF-Sand Hills-Algodon: 37 mm/yr (Behr et al., 2010)
- W. Salton Detachment: 4 mm/yr (Shirvell et al., 2009)
- Offshore: 5 mm/yr

NORTHERN GULF
- Altar-Amado-De Mar: 42 mm/yr (Pacheco et al., 2006)
- Agua Blanca: 4 mm/yr (Dixon et al., 2000)
- Incipient basins active (now in eastern GOC)
- Discontinuous(?) belts of transtension
- Narrow seaway
6 Ma

- Incipient basins active (now in eastern GOC)
- Discontinuous (?) belts of transtension
  - Narrow seaway

Distributed PAC-NAM Plate Boundary Shear
Animation of 0 - 6 Ma Reconstruction
Future Work Plan

• reconstruction steps 8, 10, 12, 14 Ma
  • 2 sets of Proto-Gulf maps
  • deformation is more diffuse
  • fewer geological constraints
• incorporate offshore faults in all model steps
  • e.g. Tosco-Abreojos fault (full 51 mm/yr)
• publish animations and GIS files of model steps
• merge with McQuarrie & Wernicke (2005) animation & GIS files (??)
Uncertain Strain Evolution

Proto-Gulf

(12.5 - 6 Ma)

What was the style and distribution of proto-Gulf deformation that preceded plate boundary localization at 6 Ma?
Uncertain Strain Evolution

Our reconstruction can evaluate feasibility of published models for strain evolution.
ACKNOWLEDGMENTS

Richard Nava
Gary Axen
Southern Gulf Reconstruction Team
  Paul Umhoefer
  Lisa Skinner
  Jared Kluesner
Thank you.