Active Intraplate Faulting in the ChileanForearc Near LaSerena (30°-31°S): Evidence from NeotectonicandGPS data

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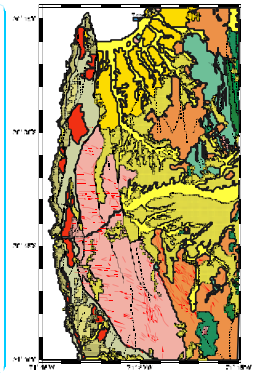
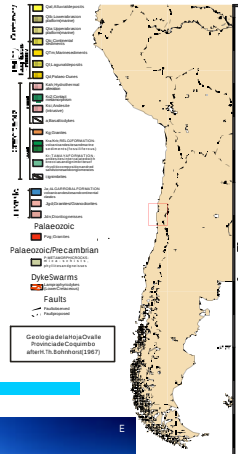
GEOLOGIC FIELD OBSERVATIONS

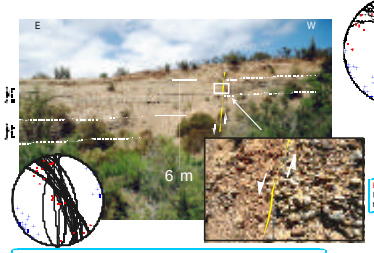
Abstract

Thisstudyfocusesonforearcdeformationand related earthquake-faulting processes and provides evidence for earthquake related surfacerupturinginthe areabetween30°Sand 31°S.
Results fromgeologicalfieldinvestigationsand recent GPS measurements were used to approximateratesoffaultingandtoevaluate superpositionand/or interaction of interplate faultingandintraplatefore-arcdeformation.

Usingelasticdislocationtheory weevaluate staticredistributionofstresses/strainsduetolarge historicalsubduction r elatedearthquakesand study associated loading and unloading phenomena alongapparentlyshallowfaults withinthehangingwallofthe Andeansubduction zone. Earthquake recurrence intervals are deducedforthe intraplatefaultsusingscaling laws,assumingthatcharacteristicearthquake faultingprevailsinthestudyarea.

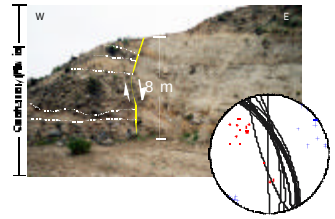




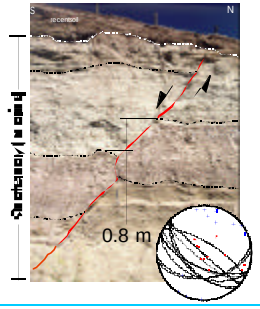


A:FaultingofQuaternarystrata5kmSofElRinconalongsidethePuertoAldeaFault. Verticaloffset6m.Evidenceforinstantaneousmotion(coseismic)fromcrushedcobbles inthefaultplane(seeinset).Fault-slipdatarevealNE-SWdirectedextensionandleftlateral strike-slipmotion.

B:Tiltedmarineterracesof Middle-UpperMioceneageatElRincon.Bedding planesdip ~30°towardsW.Fault-slipdatareveal pincipalextensiondirection trendingNE-SWandsinistralstrike-slip.

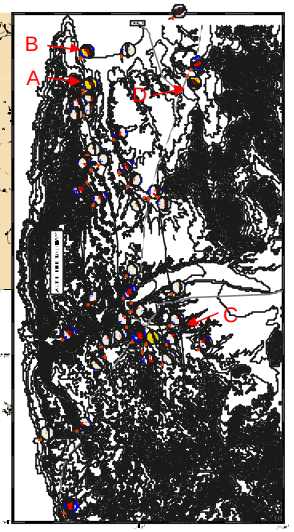


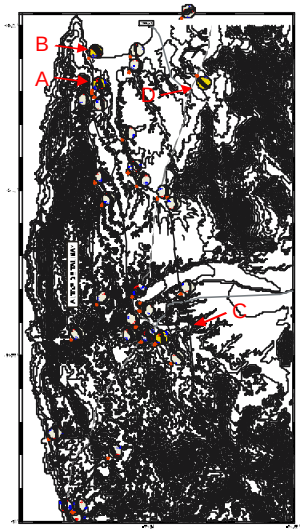
C:FaultingofQuaternary(fluvial)depositsnearTermasSocosthermalspring.Minimum verticaloffsetamountsto8m.Crushedcobblesinthefaultplanesuggestinstantaneousmotion.Fault-slipdatarevealdominantlyoblique-slipwithleft-lateralcomponent



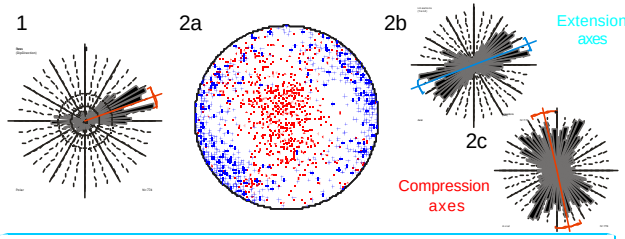
D:RoadcutalongsidethePan-AmericanHighwaynearTongoy.Verticaloffsetin Quaternary(marine)successionsis0.8m.Notethatfaultplanedipstowards SSWwhile thetopographyslopesnorthwards.Fault-slipdatarevealNNE-SSWextensionandsinistralstrike-slip.motion.

GEOLOGIC FAULT-SLIP DATA





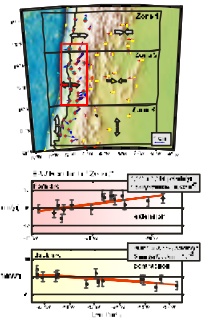
Abundantintraplatefaultingalong N-Strendingfaultswith inUpperMiocene-Quaternarystrata canbeobservedintheworkingarea. Offsetsvaryfrom0.1mto>10m.Theacross-strikedistanceofintraplatefaultsvariesbetween5-10km.Themainfault-trace,thePuerto Aldeafault,borderstheeasternrangefrontofthe"AltosdeTalinay"overalengthof50-60km. Fault-slipdatafrom47outcropsrevealextensional(leftfigure)and/orstrikeslip(rightfigure)deformation.Whileextensionalfaulting dominatestheentirestudyarea,strikeslipprincipalstraindirectionsareleft-lateralintheNandright-lateralintheS. *yellow:outcropspresentedin detail; redpoints:P-axes;bluecrosses:T-axes;50mcontourintervalsfromtopographicmap(1:50000map Instituto GeographicoMilitar,Chile)*

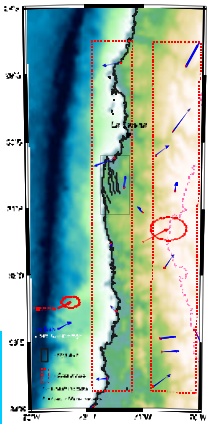


(1)Rosediagramshowingdipazimuthforthefaultplanesofthe presentedoutcropsin5°bins.Redvectordelineatesaveragedip azimuthand95%confidencelimits-N70.9°E+/-8.3°.(2a)Compositeplot(*SchmidtNetz,Lowerhemisphere*)ofprincipalstrain directionsinferredfrom774fault-slipdatasets(*blue:T-axes;red:P-axes*).(2b)Rosediagramplotst-axesazimuthssortedin5°bins. Blue vectordelineatesaverage extensiondirectionand 95%confidencelimits-N68.3°E+/-6.6°.(2c)RosediagramplotsP-axesazimuthssortedin5°bins.Redvectordelineatesaveragecompressiondirectionand95%confidencelimits-N167.8°E+/-12.3°.Note thatthedominatingcompressiondirectionis(sub)perpendicularto plateconvergencedirectionwhilethepr incip alextensiondirectionsclusterintheNEandSWquadrant.

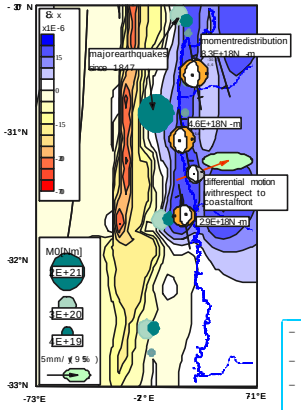
GPS RESIDUALS

Present-day crustal deformation in Northern Central Chile inferred from GPS-residualsbasedonAndeanElastic DislocationModel(*Klotzetal.,2001*). Residual velocitieswithin theforearc (red)andtheBackarc(yellow)ofZone2 areplottedseperately.Residualvelocities intheForearcindicateextensional strainsintheorderof0.049+/-0.01410 ° strain/yr. Residual velocities inthe Backarcsuggestscontractionintheorder of-0.011+/-0.003 10strain/yr.
NotethatstationslocatedintheCoastal Cordillera indicatewestward residual motions while stations in the Precordillerasuggesteastwardresidual motion. The preferred westward/eastward motion ofthestations along the Coastal Cordillera/Precordillerarespectively,indicateuniformbackmotionofthesepeneratestructuralunits.





Right:TheforearcofZone2withlocationofthestudyarea(*blackframe*).TheCoastaland Precordilleranstructuralunitsaredelineatedbyredframes.Theyareassumedtomoveas uniformblocksinducingadifferentialmotionof9.5+/-4.8mm/yr.Theazimuthofthedifferentialmotionis N65°E+/-8°.Notethatthetypeofdeformationandtheazimuthofthe extensionalstrainsinferredfromGPSresiduals(*short-term*)coincidewiththeresultsobtained bygeologic(*long-term*)fault-slipdata.



REDISTRIBUTION OF STRESSE AND STRAINS

Largedotsrepresentrecentandhistoricalearthquakesalong theplateinterface.Blacklinesindicatetracesofactiveintraplatefaultsalongwhichredistributionofstressesduetointerplate faultingwasapproximated.Contoursdepictmodeledstrainsin E-Wdirection.Thearrowandthefocalmechanismshowthedifferentialhorizontalmotionandtherelatedfaultingmechanism, assumingthatthismotionisaccomodatedalongthestudied faults.Focalmechanismdiagramsatthefaultcentersrepresentthedirectionsandamountofmomentredistributionalong thefaultplanesSeismicmomentredistributionrangesfrom2.9 -8.3*10Nmforthelast150years.
NotethatresultsfromgeologicfieldobservationsandtheinterpretationoftheGPSresidualsaswellastheresultsfromseismic momentredistributionmodelingsuggestextensionaldeformationalong majorintraplatefaultsintheforearcofthestudied area.

CONCLUSIONS

- Geologic fieldstudies i n dicate active intraplate faultinginthe AndeanForearcbetween30°-31°S.
- Surfacerelicsindicateinstantaneousmotionandsuggestthatmoderatetolargeearthquakesfrequentlyoccurinthestudyarea.
- Differentialmotioninferredfrom GPSresidualssuggestsextensional deformationinthestudiedsegmentoftheAndeanForearc.
- Assuming characteristic earthquakestherecurrenceintervalfor M= 7eventsalongthePuertoAldeaFaults470+/-140yrs.
- Modelingthedistributionofstressesand strainsrevealsanextra loadofextensionalstrainsimposedonintraplatefaultsduringrupture of greatsubductionearthquakes.

REFERENCES
Klotz,J.,G.Khazaradze,D.Angermann,C.Reigber,R. Perdomo,and O.,andCifuentes,Earthquakecycle dominatescontemporarycrustaldeformationinCentral and SouthernAndes, *EarthPlanet.Sci.Lett.,inprint*,2001.