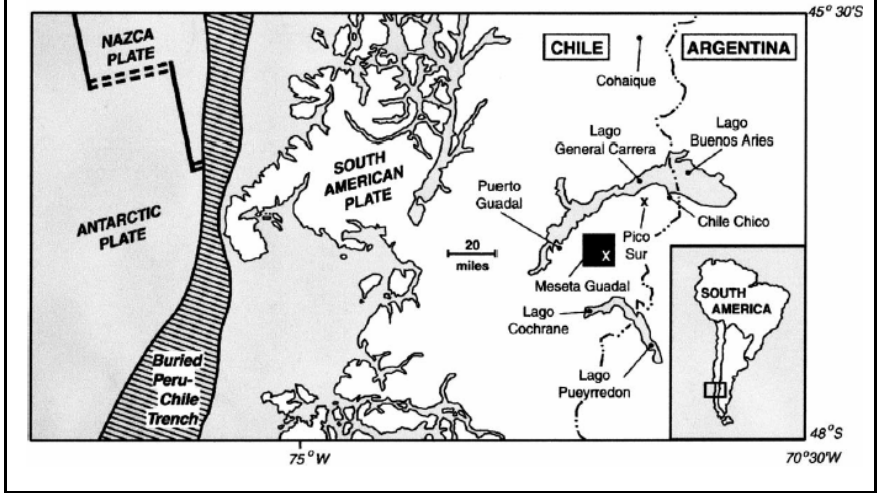
Tectonics of South America: Chile Triple Junction

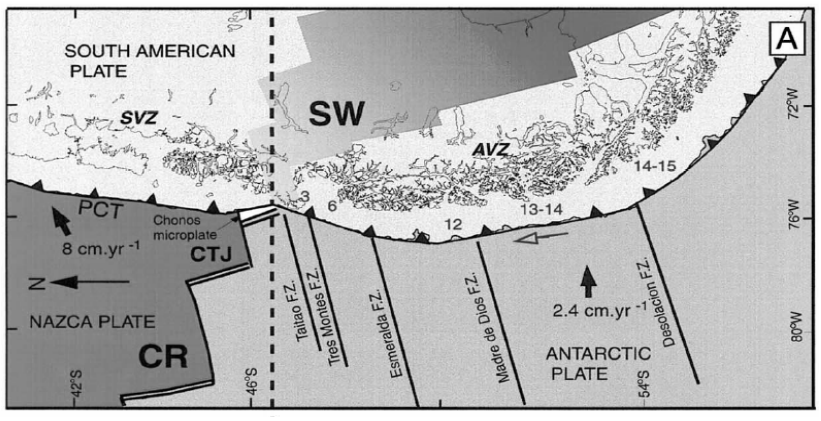
Kelly McGuire

April 8, 2004

Triple Junction as it is Today



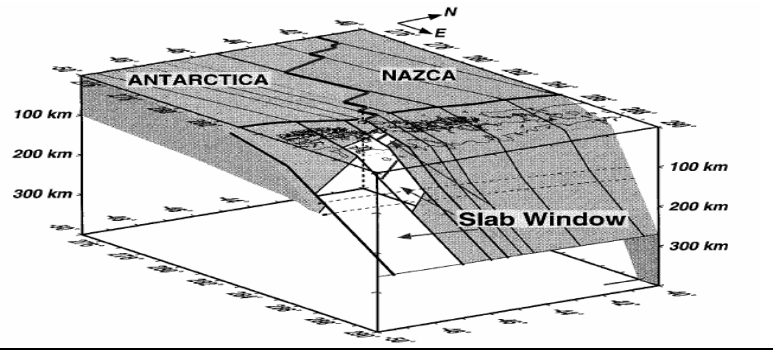
*Chile Triple Junction 46.5°S, 75.5°W
*Nazca Plate Motion 8 cm/yr, NE direction
*Antarctic Plate Moving 2.4 cm/yr, E direction
*Spreading Ridges form between Nazca Plate and Antarctic Plate



Subduction

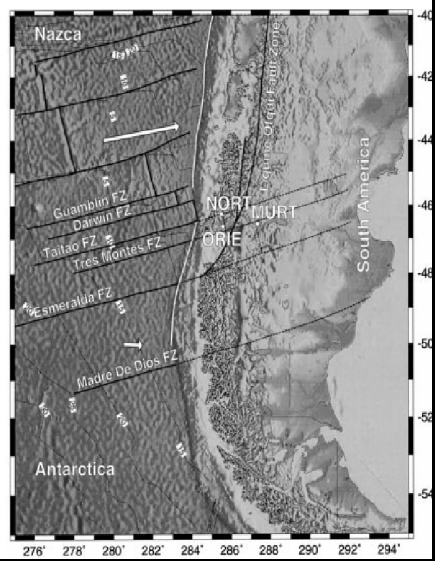
- Flat Slab Subduction Suggested for the Nazca Plate.
  - Young, less dense oceanic crust gets subducted under continental crust.
  - Relatively low angle of subduction (5-15°)
  - Relationship of flat slab subductin and fold belts were developed further into plates interior
    - By foreland basement thrust systems
- Steep Slab Effects
  - Intense Young, Calc Alkaline Volcanism

- Where Rise Enters the Trench it is Very Shallow
- Trend of Rise is WNW
  - Ridge Segments striking West of North
- Ridge Segments Approach Trench at Shallow Angle
- Chile Rise Transforms Enter Ridge at a High Angle



Recent Subduction

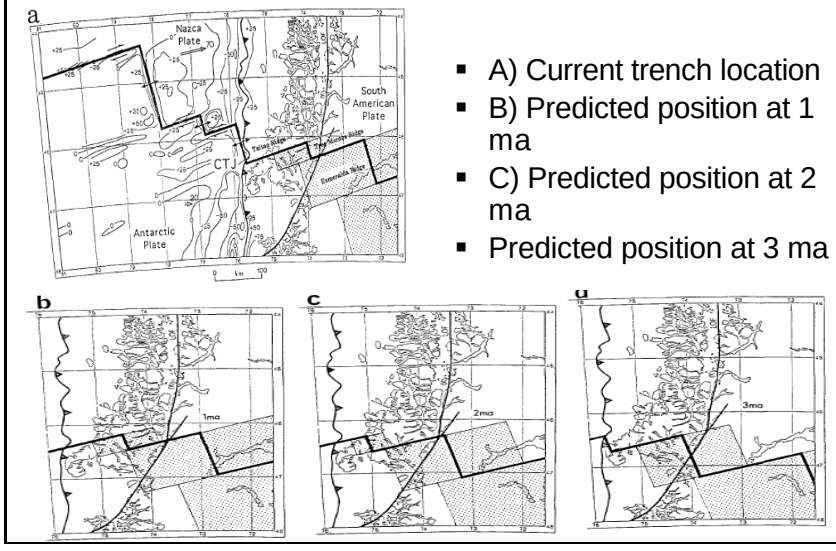
- Just off the Taitao-Tres Montes Peninsulas
- Between the Taitao and Darwin Fractures. Associated with:
  - Structure of continental forarc
  - Obduction of a Plio-Pleistocene ophiolite sequence
  - Recent Volcanism of the Tres Montes Pen.
  - Gap in active Pantogonian Volcanic arc
  - Eruption of plateau basalts in W. Argentina



What Has Been Found on the Taitao Peninsula

- Plutons - ~17 km East of the Trench Axis
  - Biotite–hornblende-bearing granodiorite or tonalite
- Bimodal Dike Complex
- Volcanic Edifices on Eastern Peninsula, With Little Deformation

Predicted Positions of Slab Window



- A) Current trench location
- B) Predicted position at 1 ma
- C) Predicted position at 2 ma
- Predicted position at 3 ma

Effects of Ridge Subduction

- Pliocene Near-Trench Magmatism,
  - Intrusion of calc-alkaline stocks within the forearc basement
  - Creation of the Taitao Ophiolite at leading edge of SA
- Distribution and Kinematics of Faulting
  - Reflects the plate margin kinematics
  - Strongly influenced by the thermal, topographic and kinematic heterogeneities related to the CTJ
- 1000 km Long, Trench Parallel, Liquifie Ofqui Fault.
- All These Effects are Found Within 100 km of the Trench

Effects of Ridge Subduction Cont.

- Cenozoic Uplift of the Andean Divide Appears to be Dramatically Different N & S of the Triple Junction
- Back Arc Fold and Thrust Belt of Southernmost Patagonia Appears to End at the Present Latitude of the Triple Junction
  - Corresponds to a change in thickness of Miocene molasse.
  - Passage of slab windows corresponding to ridge
- Slab Window Movement Corresponds to Ridge Segments Subducted in the Late Cenozoic

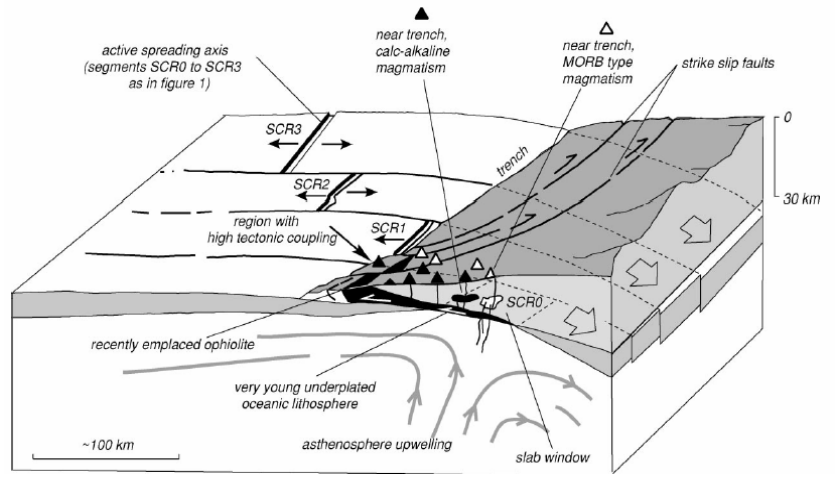
What's so cool about the CTJ?

- Ridge-Trench-Trench (RTT) Triple Junction
  - Where active oceanic spreading ridges enter a subduction zone.
  - Instead of mature oceanic crust subducting, younger crust created from the extension of the triple ridge is subducting.
  - Repeated passages can develop high thermal gradiants.
    - Can allow rocks or oceanic or continental origin to melt at:
      - T= 800-900°C and Pressure corresponding to depths of 10-20km

What is going on?

- Calc-Alkaline Acidic Rocks are not Expected to Occur in this Type of Margin.
- Possible Scenario
  - Tectonic coupling along with repeated passage of thermal anomalies which is due to successive subduction of short ridge segments.
  - Tectonic coupling leads to the underplating of very young hot lithosphere to the continental margin.
  - Repeated ridge subductions favor the re-melting of the underplated oceanic material.
  - This would result in calc-alkaline acidic rocks, associated with MORB-type lavas.

Tectonic Model



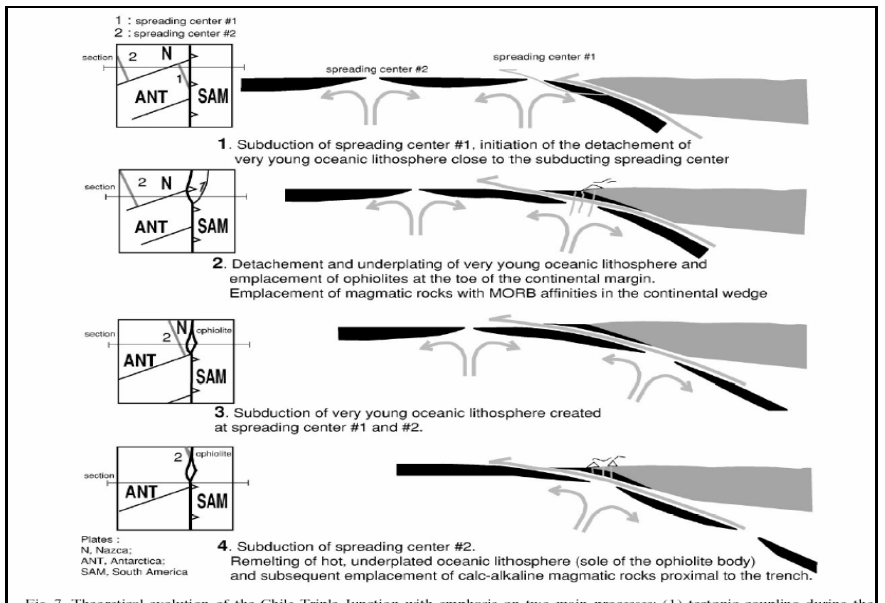
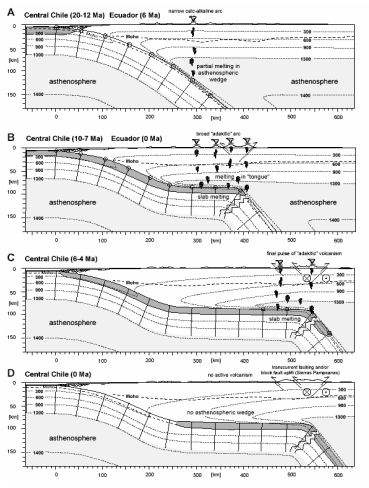


Fig. 7. Theoretical evolution of the Chile Triple Junction with emphasis on two main processes: (1) tectonic coupling during the subduction of active spreading ridge segments, ophiolite emplacement and underplating of young oceanic material at the toe of the continental margin; and (2) repeated subduction of very young oceanic lithosphere and active spreading ridges segments leading to the development of a long-lived thermal anomaly in the forearc and thus re-melting of underplated oceanic material.

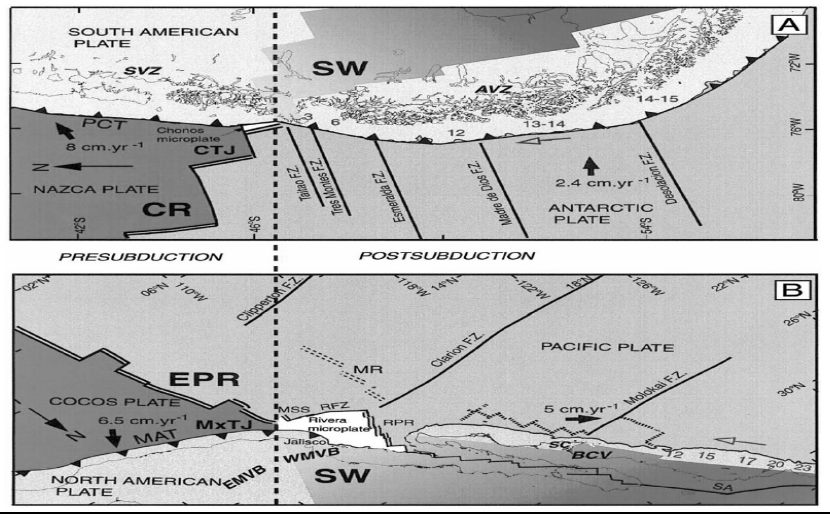
A Different Model



- Showing transition from Steep to shallow subduction.
- Simulating 20ma – present.
- This includes partial melting of the slab.
  - Which leads to an absence of the Asthenosphere Wedge presently.

Comparison

Mexican Triple Junction:



Comparison Continued

- Compared to the triple junction in the US Creation of the Cascade Mountains.
  - Although the same volcanism is not found here.
  - No trench in the Juan de Fuca plate system.
  - Similar triple junciton but not really a good comparison.

Subduction WNA

- Compared to Subduction of the Western Edge of North America ~ 20 ma
  - Closest thing happening today, which is the subduction of an active spreading ridge at a continental margin
  - Because an active spreading ridge is being subducted we may be able to get a better understanding the San Andreas Fault System

Conclusions

- Most Models Propose a Slab Window
  - With some sort of shallow subduction
- Most Agreed that the Slab had a Faster Motion North With Subducting the Ridges, and a Slower Motion South While Subducting Trenches.

References

- Bourgois, J., 2002, Comparison between the Chile and Mexico triple junction areas substantiates slab window development beneath northwestern Mexico during the past 12^10 Myr, Earth and Planetary Science Letters 201 35-44
- FLINT, S., PRIOR, D., AGAR, S., TURNER P., 1994,Stratigraphic and structural evolution of the Tertiary Cosmelli Basin and its relationship to the Chile triple junction, Journal of the Geological Society, London, 151 251-268
- Flynn, J., Novacek, M., Dodson, H., Frassinetti, D., McKenna, M., Norell, M., Sears, K., Swisher, C., Wyss, A., 2002, A new fossil mammal assemblage from the southern Chilean Andes: implications for geology, geochronology, and tectonics Journal of South American Earth Sciences 15 285–302
- Guivel, C., Lagabrielle Y., Bourgois, J., Mauryc, R.C., Fourcaded,S., Martin, H., Arnaud, N., 1999, New geochemical constraints for the origin of ridge-subduction-related plutonic and volcanic suites from the Chile Triple Junction (Taitao Peninsula and Site 862, LEG ODP141 on the Taitao Ridge), Tectonophysics 311 83–111
- New geochemical constraints for the origin of ridge-subduction-related
- plutonic and volcanic suites from the Chile Triple Junction
- (Taitao Peninsula and Site 862, LEG ODP141 on the Taitao Ridge)
- Marc-André Gutscher, MA., Maury, R., Eissen, JP., Bourdon, E., 2000, Can slab melting be caused by flat subduction?Geology 28, 6, 535-538
- Jacques, J., 2003, A tectonostratigraphic synthesis of the Sub-Andean basins: implications for the geotectonic segmentation of the Andean Belt, Journal of the Geological Society, London, 160,687–701
- Lagabrielle, Y., Guivel, C., Maury, R., Bourgois, J., Fourcade, S., Martin, H., 2000, Magmatic–tectonic effects of high thermal regime at the site of active ridge subduction: the Chile Triple Junction model, Tectonophysics, 326, 255-268
- Murdiena, R., Russob, R., 1999, Seismic anisotropy in the region of the Chile margin triple junction, Journal of South American Earth Sciences, 12 261-270
- Suarez, M., De La Cruz, R., Bell, C., 2000, Timing and origin of deformation along the Patagonian fold thrust belt, Geological Magazine, 137,4,345-353