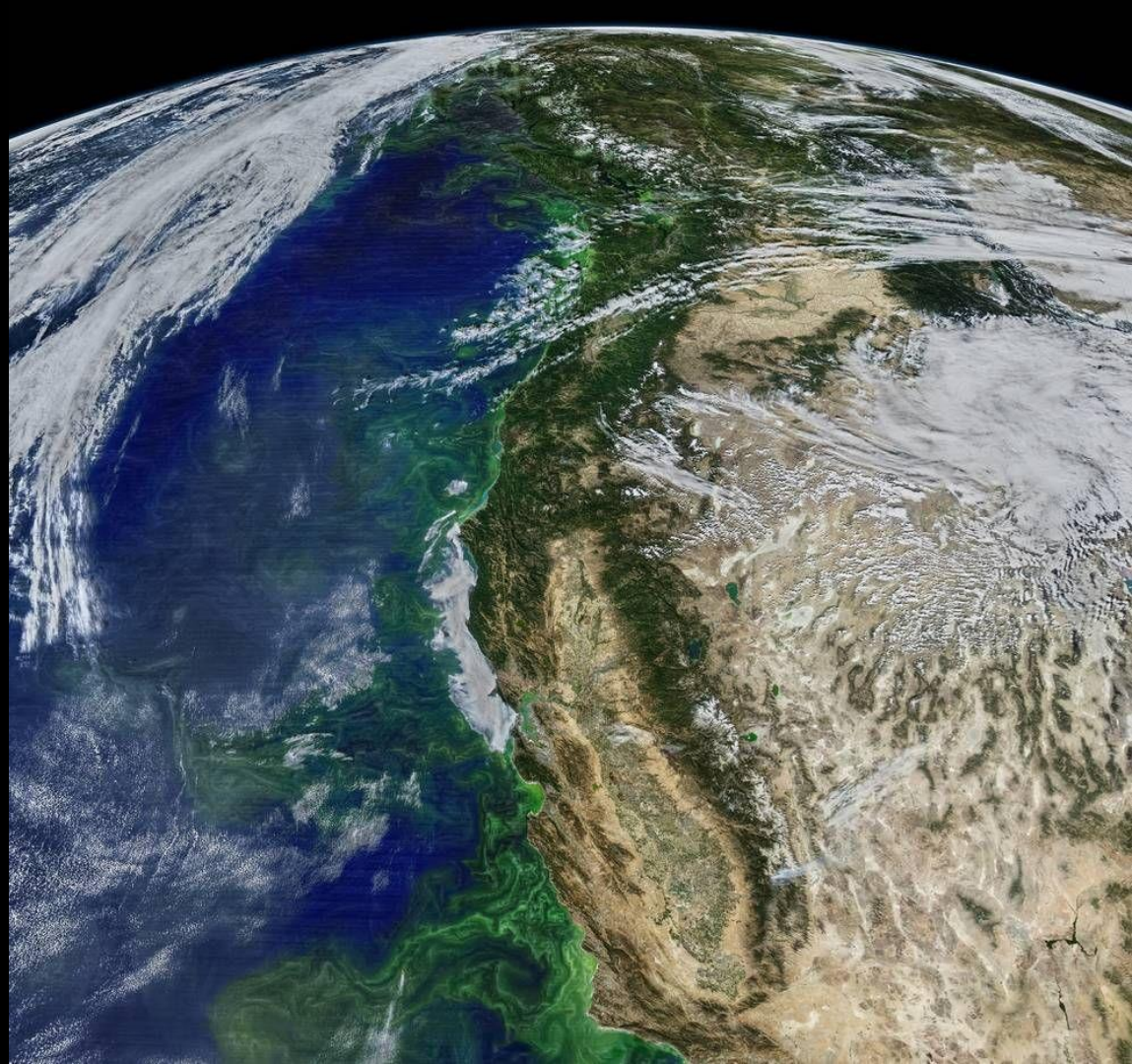
Evolution of Triple Junctions in North-East Pacific

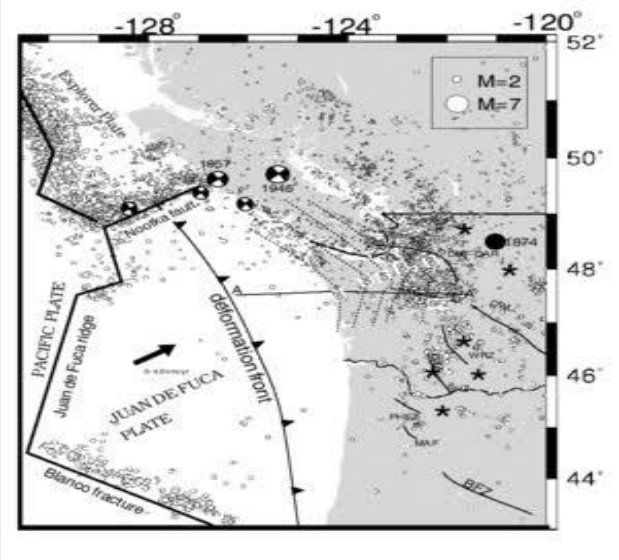
Om M Vaknalli (18376)



Triple Junction

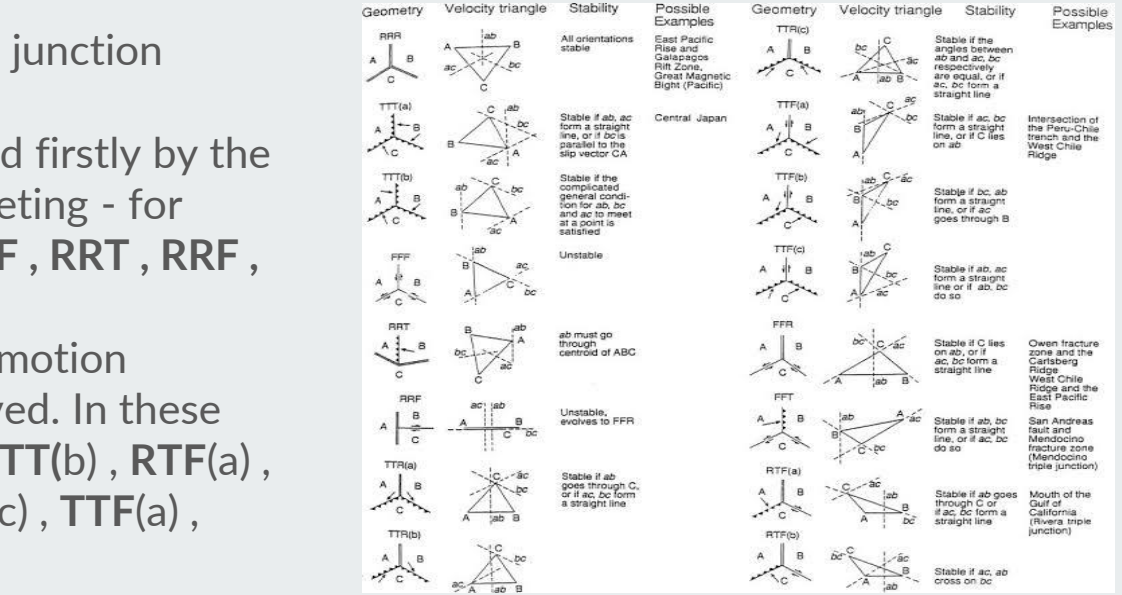
A Triple Junction is point where the boundaries of three tectonic plates meet.

At Triple Junction each of the three boundry will of one of three types - a **ridge**(R) ,**trench**(T) **or transform fault**(F)



Types Of Triple Junction

- There were **16 types** of triple junction theoretically possiable.
- These junction were classified firstly by the types of plate boundaries meeting - for example **RRR , TTT , FFF , RTF , RRT , RRF , TTF , TTR , FFR** and **FFT.**
- And secondly by the relative motion directions of the plates involved. In these category we bave - **TTT**(a) , **TTT(**b) , **RTF**(a) , **RTF**(b) , **TTR**(a) ,**TTR**(b) , **TTR**(c) , **TTF**(a) , **TTF**(b) and **TTF**(c).



Stability of triple junctions

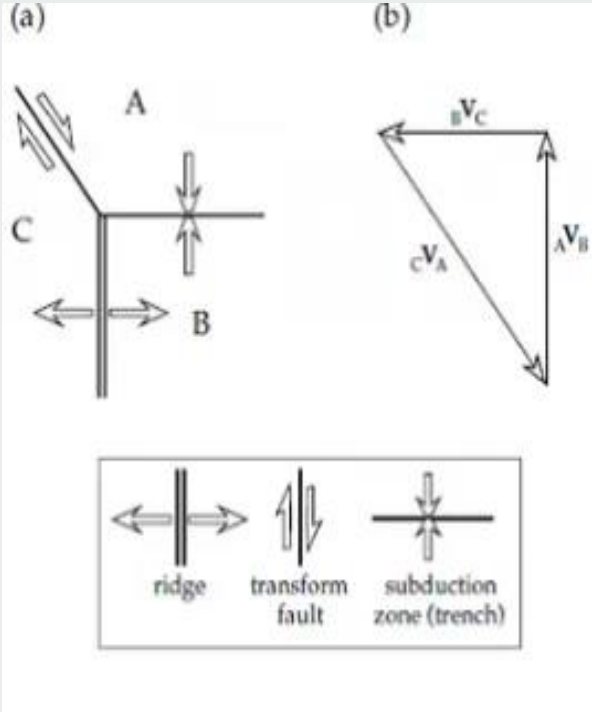
⟹ For a junction to preserve its geometry , the orientations of three plate boundaries must fulfil conditions which allow the relative velocity to satisfy the equation aVb + bVc + cVa = 0 (fig. b).

⟹ If they do so the junction is stable and can maintain its shape . Otherwise the junction is unstable and must evolve in time to a stable configuration .

⟹ The stability of triple junction is assessed by considering how it can move along any of the plate boundaries that form it .

⟹ In the present phase of plate tectonics only a few of the possible types of triple junctions appear to be active .

⟹ An unstable triple junction will change with time , either to become another form of triple junction , will change geometry or are simply not feasible .



A magnetic anomaly is a local variation in the earth magnetic field ie Variation in the magnetism of the rock. The anomalies can be identified by interpreting their shape.

Oceanic magnetic anomalies in the north east pacific form a complex stripped pattern.

Age found by comparison with a geomagnetic polarity time scale.

It gives the age of each numbered chrom since the late jurassic.

In the north east pacific the anomalies become younger toward the north american continent in the east and toward the Aleutian trench in the north

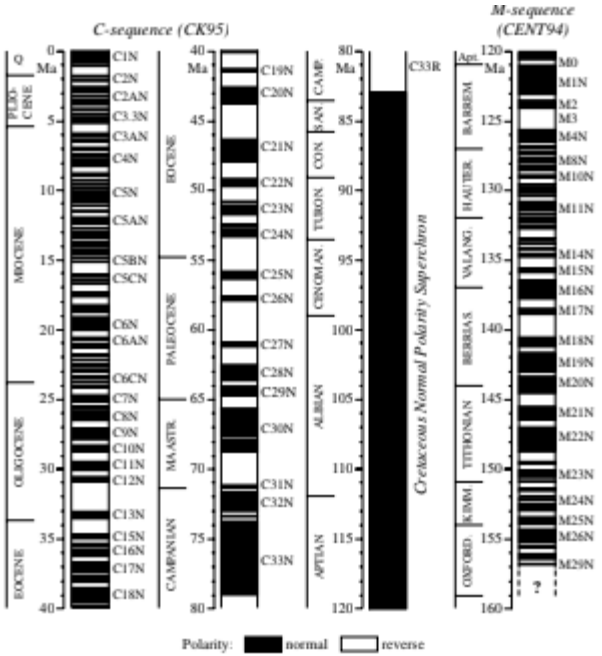


Fig. 5.78 The geomagnetic polarity timescale since the late Jurassic, derived from the interpretation of marine magnetic anomalies and calibrated by coordinated magnetostratigraphy and biostratigraphy. The polarity record of the C-sequence anomalies for the past 85 Ma (CK95) was revised by Cande and Kent (1995); the M-sequence record from 120 Ma to 157 Ma (CENT94) is that of Channell *et al.* (1995). The record of reversals prior to about 155 Ma is uncertain.

The anomaly pattern produced at ridge is usually symmetric .

But in the north east pacific only the western half of the anomaly pattern is observed.

The plate on which the eastern half of the anomaly pattern is formed called farallon plate.

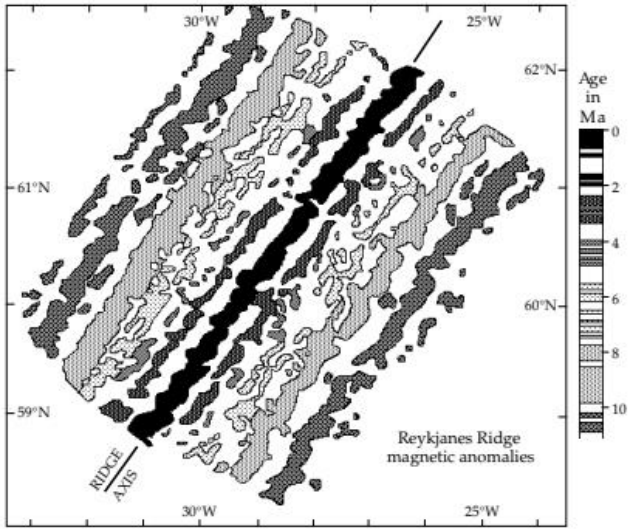


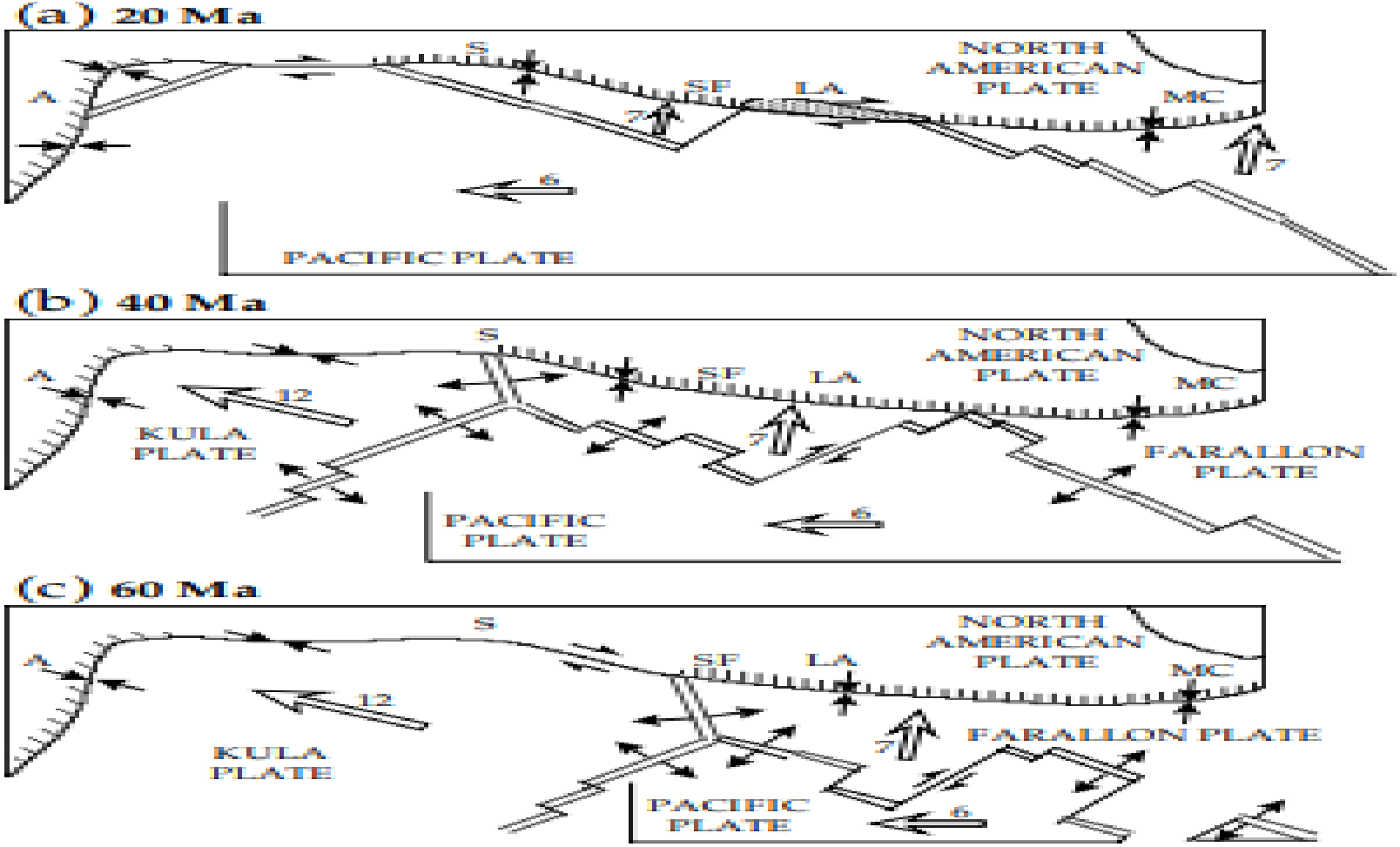
Fig. 1.13 Symmetric striped pattern of magnetic anomalies on the Reykjanes segment of the Mid-Atlantic Ridge southwest of Iceland. The positive anomalies are shaded according to their age, as indicated in the vertical column (after Heirtzler *et al.*, 1966).

The evolution of triple junctions in the northeast-Pacific Assignment 1

In the Farallon Plate only 2 small pieces of this still exists which are following :

1. Juan de Fuca Plate (off the coast of British Columbia)
2. Rivera plate (At the mouth of the Gulf of California).

The magnetic anomalies indicates that there used to be another plate called the Kula Plate but now it is consumed under Alaska and Aleutian trench. The next diagram can clear things a little bit.


(a) 20 Ma
S
A
SF
LA
NORTH AMERICAN PLATE
MC
7
6
PACIFIC PLATE
(b) 40 Ma
S
A
12
KULA PLATE
SF
LA
NORTH AMERICAN PLATE
MC
7
FARALLON PLATE
PACIFIC PLATE
6
(c) 60 Ma
S
A
12
KULA PLATE
SF
LA
NORTH AMERICAN PLATE
MC
7
FARALLON PLATE
PACIFIC PLATE
6

Assignment 1

According to the previous diagram we can see that about 60 Million years ago the Pacific, Kula. and the Farallon Plate were diverging and forming a RRR (Ridge-Ridge-Ridge) type triple junction.

And we know that this type of triple junctions are stable and preserves its shapes during subsequent evolutions. So therefore it was possible to reconstruct the motion of these plates .

EVOLUTION OF TRIPLE JUNCTION IN NE PACIFIC OCEAN

Sea floor spreading rate

Gulf of California California = 3cm/year

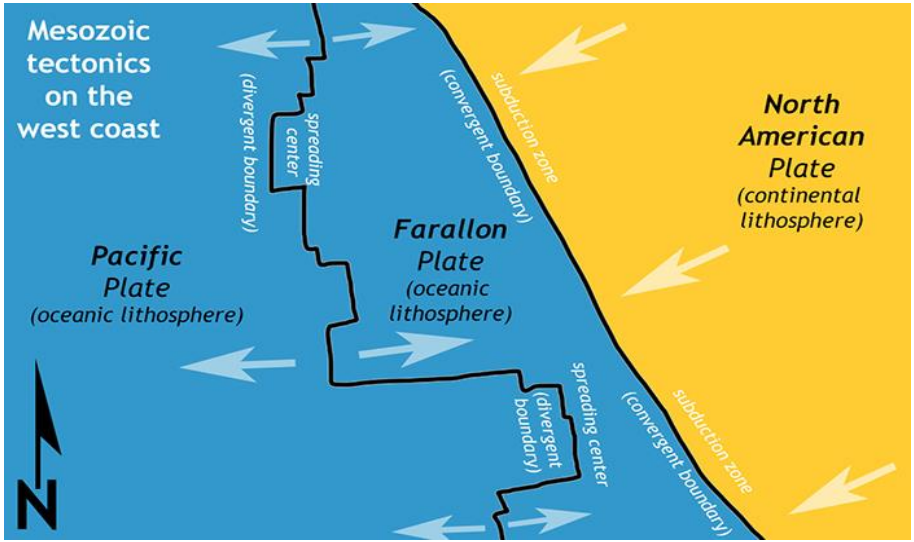
Farallon–Pacific ridge = 5cm/ yr

relative velocity =10cm

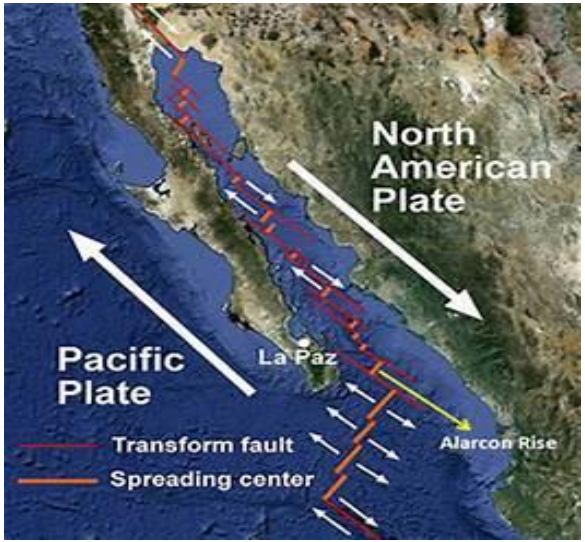
Farallon plate on the American plate =7cm/year

Direction of Relative Motions of Plates

Pacific-Farallon -North American plates -



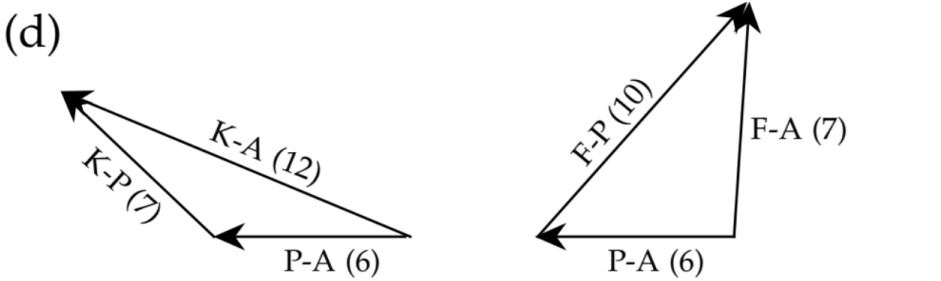
Gulf of California



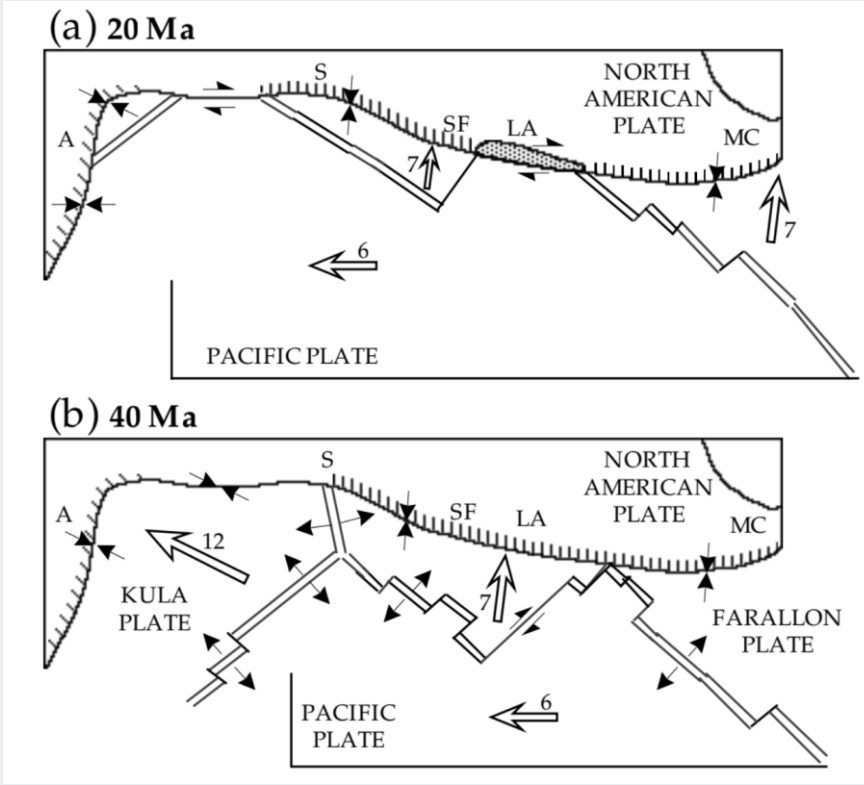
Farallon - Pacific - Kula - American Triple Junctions

Provides good Examples of:

- Triple Junction Creation & Destruction
- Plate Velocity Estimation

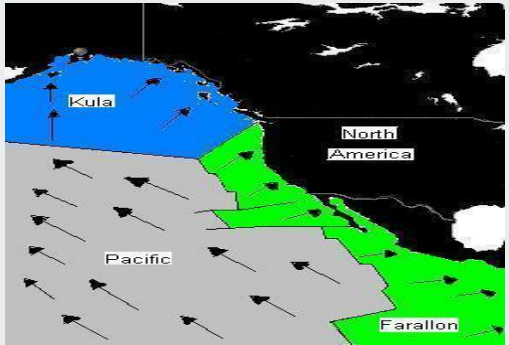


(d) Vector diagrams of the relative plate velocities at the Kula–Pacific–American and Farallon–Pacific–American triple junctions (numbers are velocities in cm yr^{-1} relative to the American plate).



Cenozoic era, 66 mya until present was the time interval during which continents assumed their modern configuration and geographic position, earth's flora and fauna evolved. It involved rotations of strike-strip faults,continuous blocks and oceanic plates,spreading of marginal seas and formation of hydrocarbon bearing basin. The combined effect of interactions of Eurasian,Pacific and Indo-Australian plates and collision of India with Eurasia and of Australia with South East Asia. Some examples being:

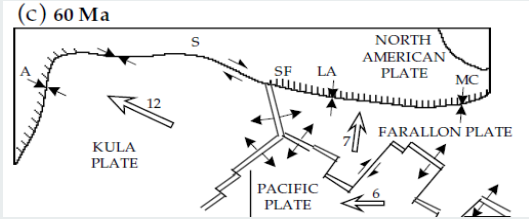
American pacific motion-late cretaceous 4Mya
It is evident that the triple junction formed and migrated along the American plate margin throughout.



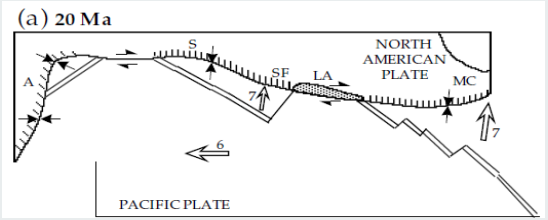
Kula Pacific Farallon motion- late cretaceous 80 mya
Triple junction of three ridges between Kula plate(N),Pacific(W) and Farallon (E). Kula plate subducted under North American plate so Canadian Rockies composed of sediment sheets. While shallow subduction of Farallon plates helped in continental upliftment of American Rockies.

DEVELOPMENT OF KULA-AMERICAN-FARALLON RTF JUNCTION AND FFT JUNCTION

The Pacific-Farallon Ridge was a spreading ridge during the late Cretaceous that extended 10,000 km in length and separated the Pacific Plates to the west and the Farallon Plate to the east.As the Farallon-Plate subducted **the Pacific-Farallon Ridge approached** and eventually made contact with North American Plate about 30 MYA.**The Farallon-Trench** was subduction related tectonic formation located off the coast of the **Western California continental margin** during the late to mid cenozoic era. The collision and subduction of the **Farallon–Pacific ridge** at the **Farallon– American trench** resulted in the development of **Kula American Farallon RTF and FFT Junction.**



Kula-American-Farallon RTF Junction:-Slightly north of the present location of San Francisco 60 Ma ago as shown in Fig-(c) and it moved to a north of seattle in 20 Ma ago as shown in Fig-(a).



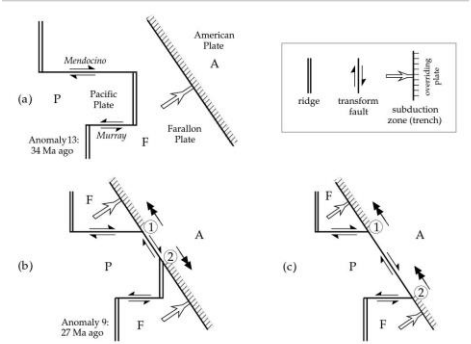
FFT Junction:-Oligocene an FFT junction formed between San Francisco and Los Angeles, while the Farallon– Pacific–American RTF junction evolved to the south.

What happened after the Oligocene period?

At the time 34 Million years ago the time of magnetic anomaly 13 there's also a change which causes the evolution of Triple Junction in NE Pacific even further.

What exactly has happened?

At the time of 13th magnetic anomaly a north–south striking ridge joined the Mendocino and Murray transform faults as part of the Farallon–Pacific plate margin to the west of the American trench.



By the time of anomaly 9, about 27Ma ago, the ridge had collided with the trench and been partly consumed by it.

The Farallon plate now consisted of two fragments:

- an FFT junction developed
- an RTF junction formed

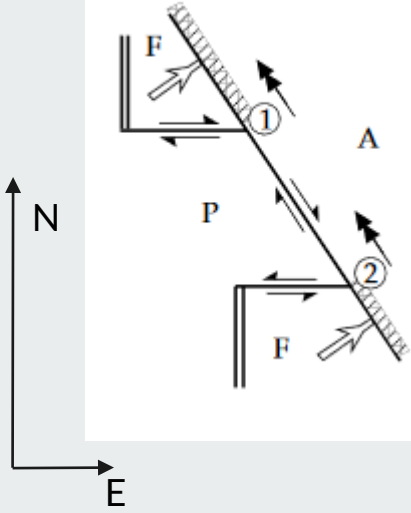
FFT & RTF junctions in San Andreas

*junction 1 is FFT and junction 2 is RTF.

*Both 1 and 2 are stable when trenches are parallel to transform faults along the san andreas system.

*after analysis of vector velocity diagram of point 1 & 2 we get that:
Point 1 migrated to Northwest and point 2 migrated to southeast.

*Later the Murray transform fault changed the junction at point 2 to an FFT junction when the southern segment of the Farralon-Pacific subducted under the american plate.



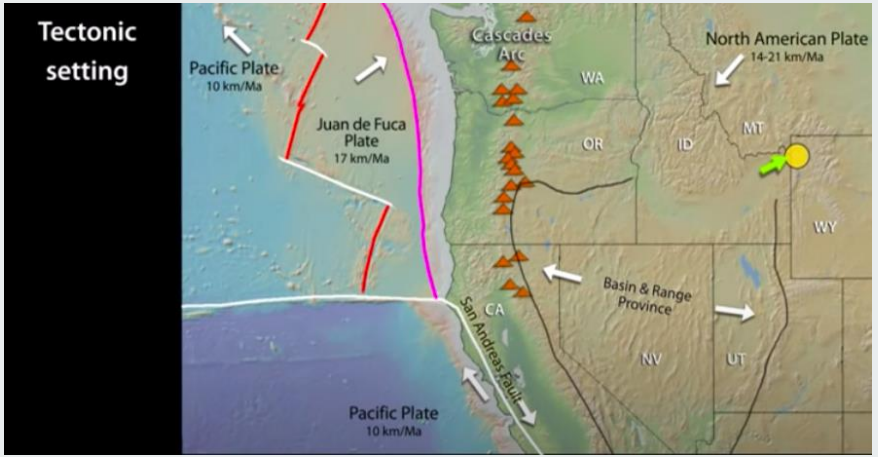
Cenozoic Volcanism in the Pacific Northwest

(55 my in a complex tectonic setting)

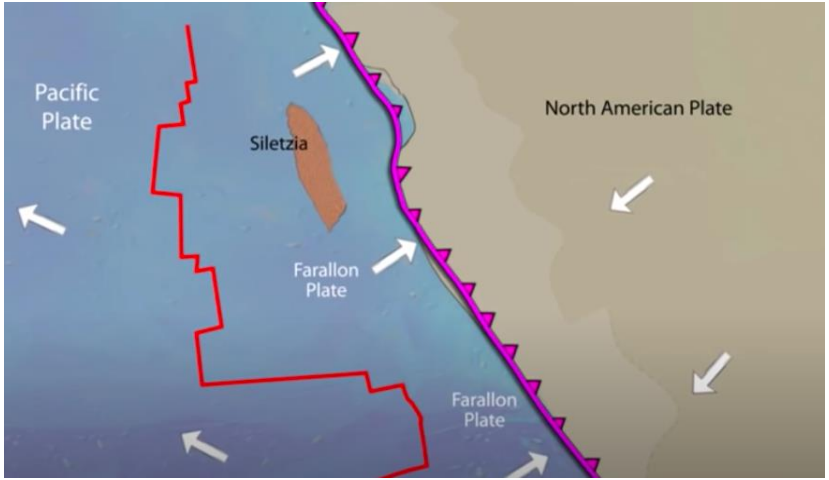
1. Ocean Ridge Rifting produces submarine volcanoes offshore.

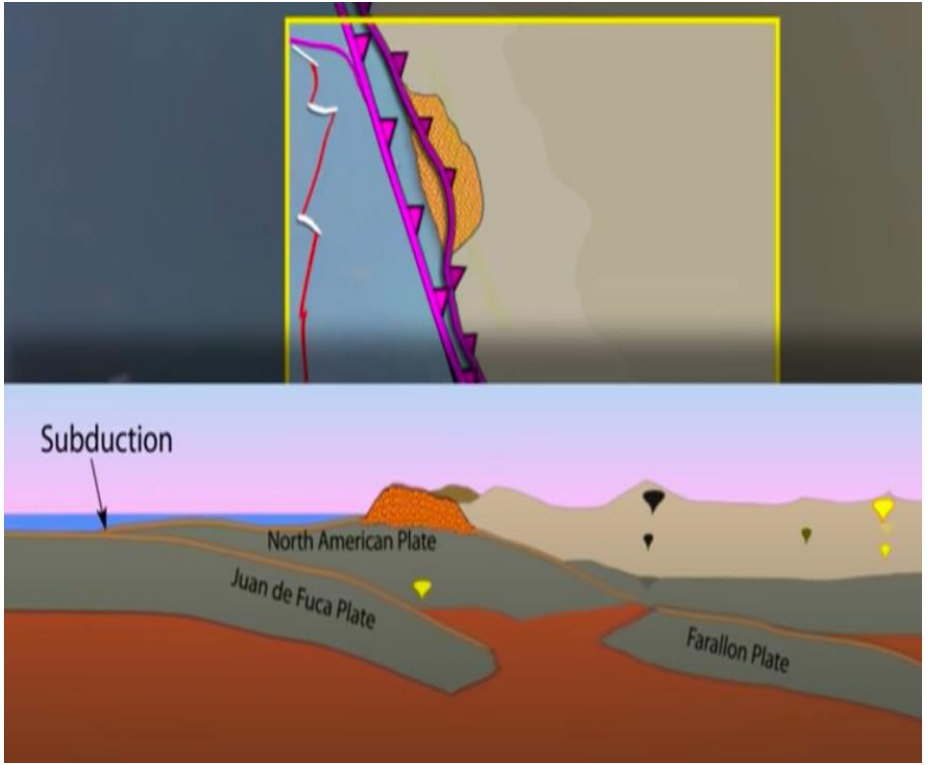
2. Cascade arc formed by Juan de Fuca Plate.

3. Hotspot volcanism drives Yellowstone Caldera System.



Siletzia on Farallon plate collides with American plate and the plate then subducts beneath the American plate leaving the remnant Juan De Fuca plate offshore





Thank - You!