

Earth Fissure Disaster in East African Rift System



Jianbin Peng (彭建兵),
Chang'an University

Earth Fissure Disaster in East African Rift System

Outline

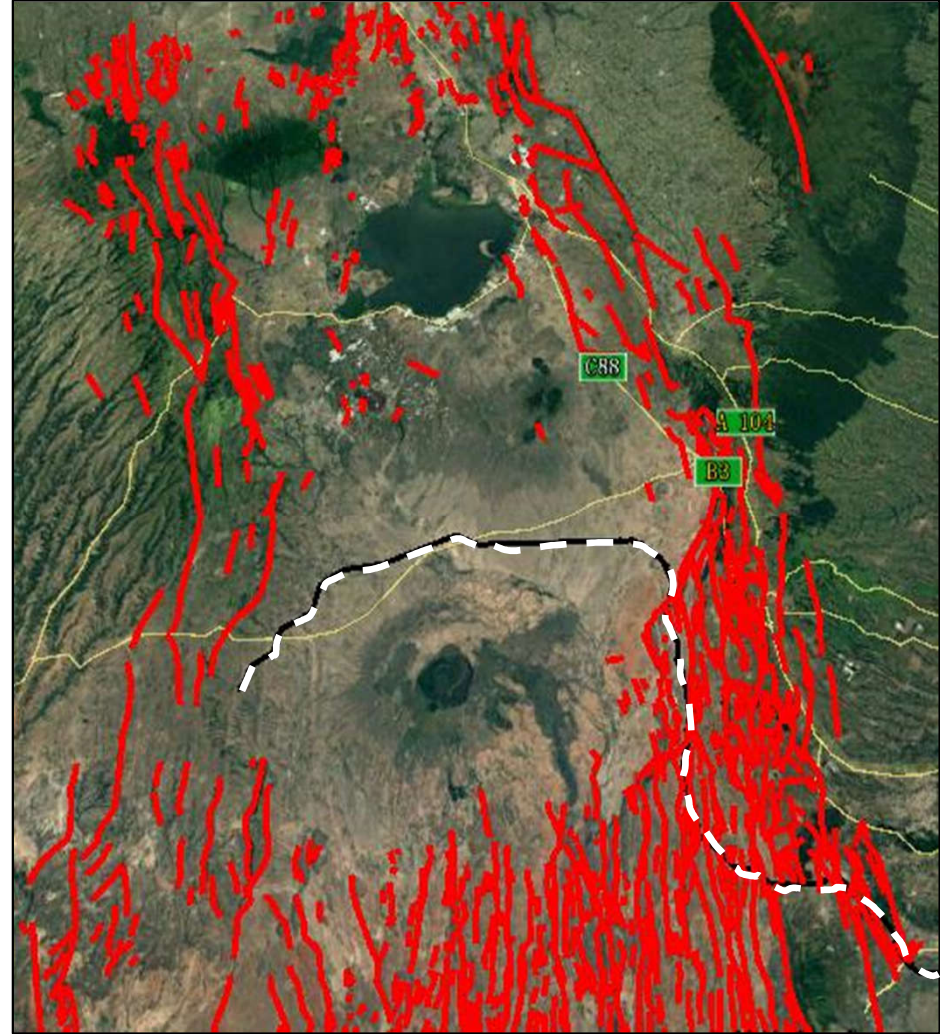
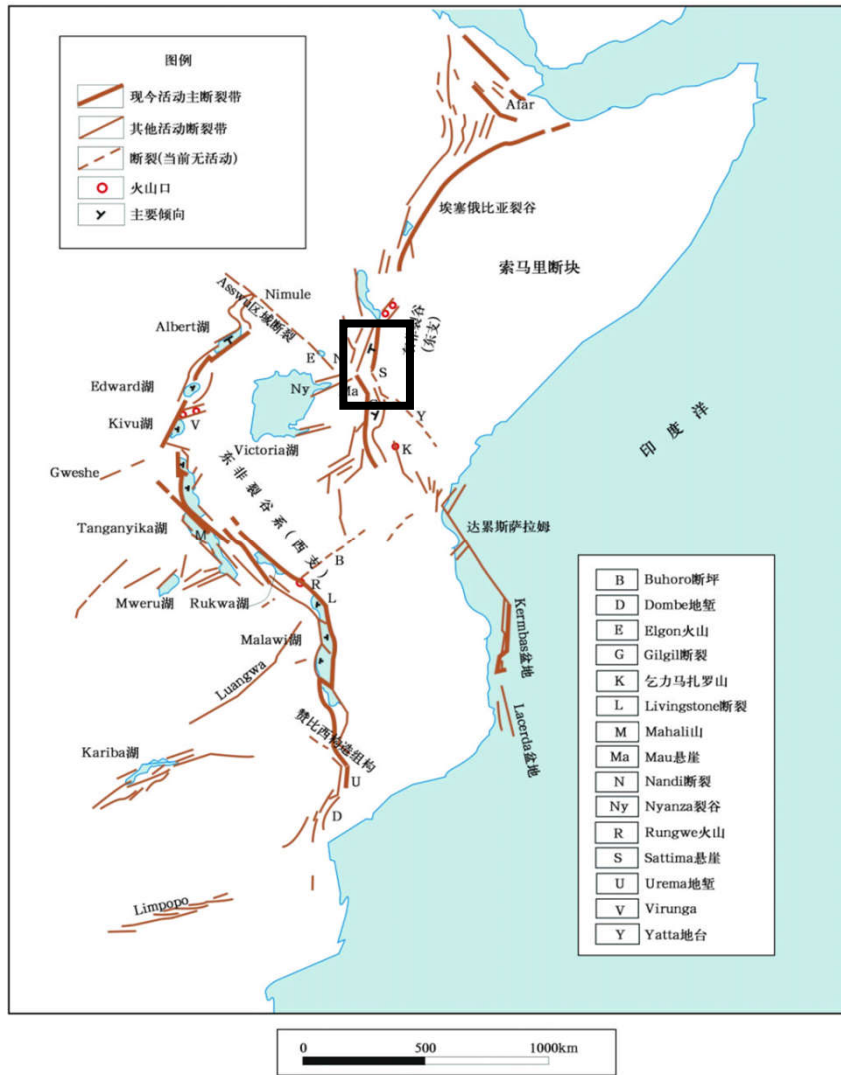
1. An overview of the earth fissure in Kenya of the east African Rift
2. Tectonic features and continental dynamics background of east Africa Rift
3. Earthquake and volcanic activity in east Africa Rift
4. The mechanism of earth fissure in east African Rift

An overview of the earth's fissure in Kenya in the eastern African Rift

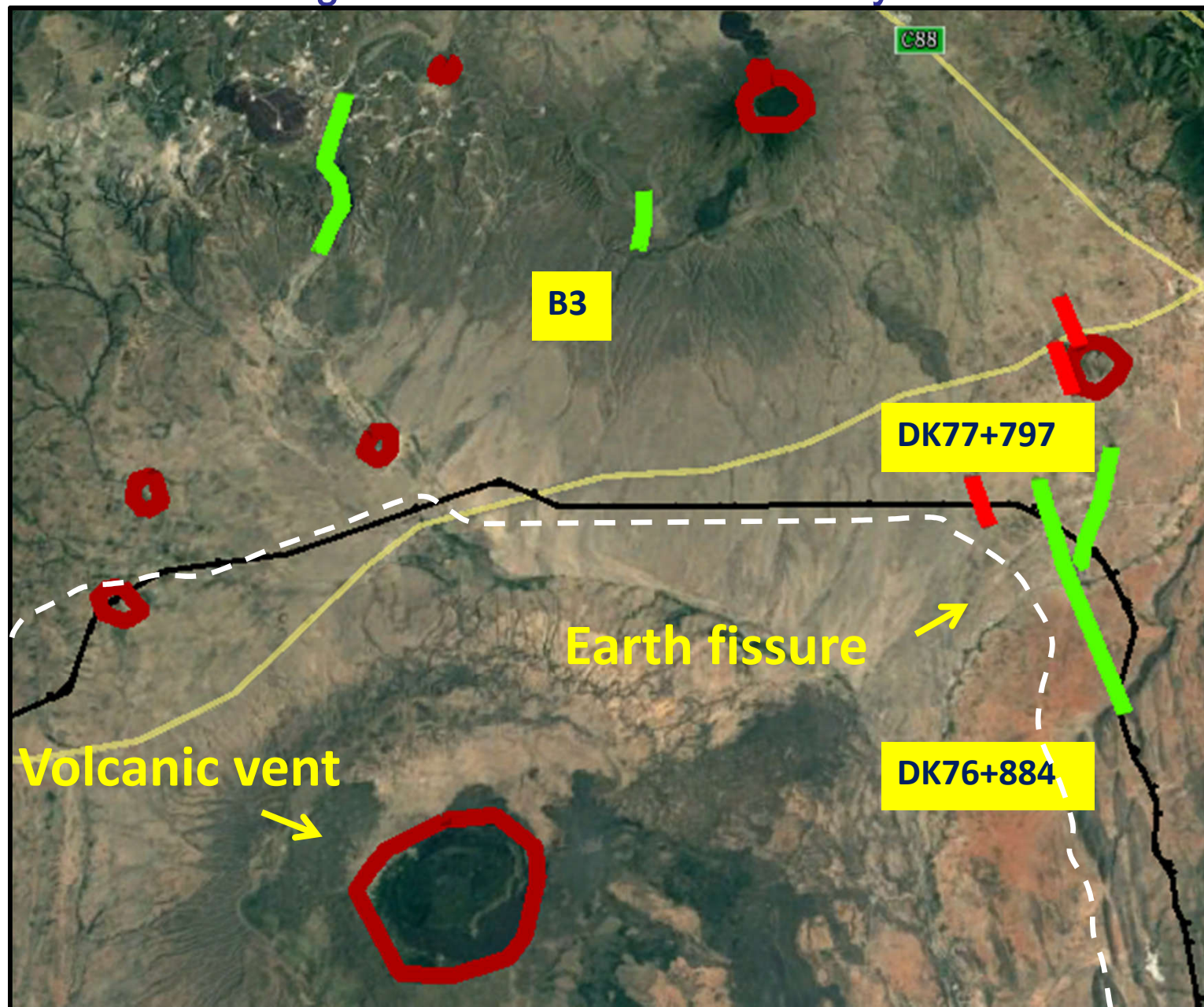
The railway of Mombasa to Nairobi is the bridge tower of the “one belt and one road” project, and also is a landmark engineering of cooperation between China and Africa.



The geological conditions across the rift valley appear to be good?



From March to May 2018, 4 earth fissures were formed by sudden surface cracking at the bottom of the rift valley area



**Inside
Africa**

IN ASSOCIATION WITH



Big crack is evidence that East Africa could be splitting in two

By Lucia Perez Diaz, CNN

🕒 Updated 9:31 AM ET, Fri April 6, 2018



Striking length of earth fissures up to 20 m across B3 highway



DK77 earth fissure has 500 m long and crossing the railway line

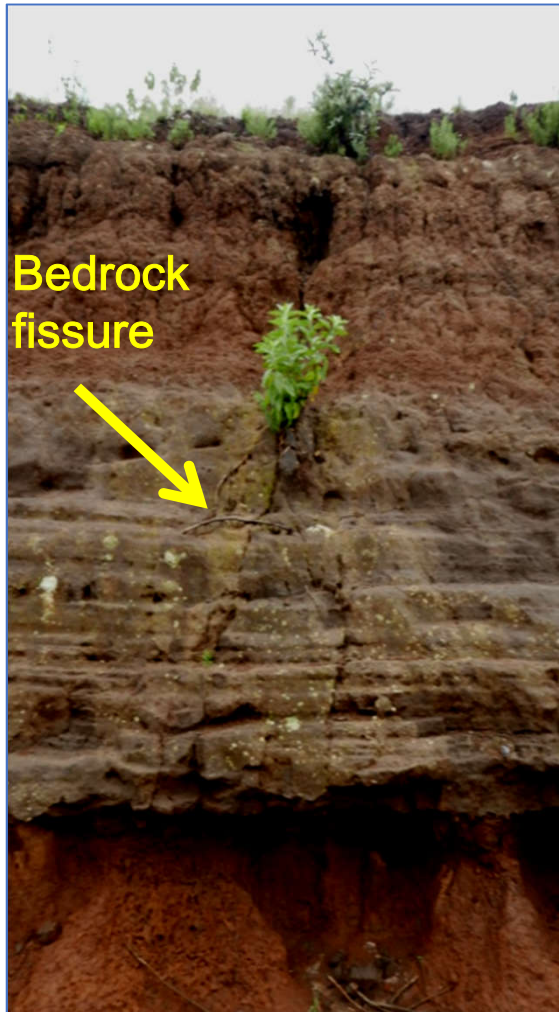


At present, earth fissure are mainly divided into two types:

- 1. developed along with normal faults**
- 2. developed along with bedrock fissure zone.**

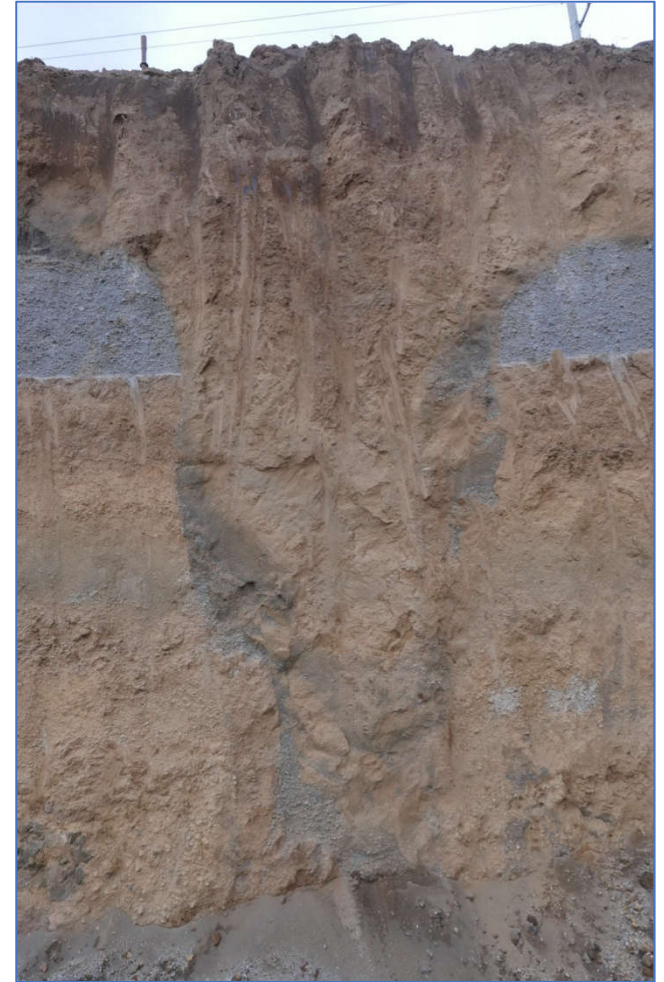


Earth fissure developed along with normal faults



Earth fissure developed along bedrock fissure zone.

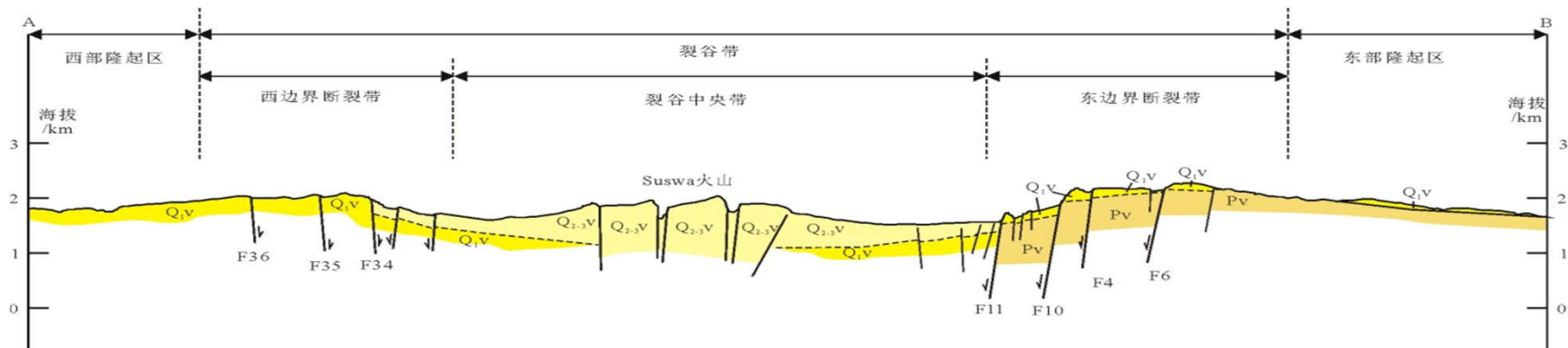
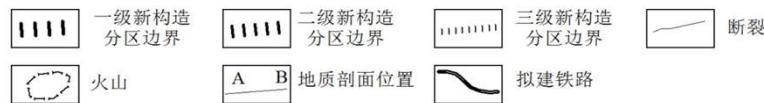
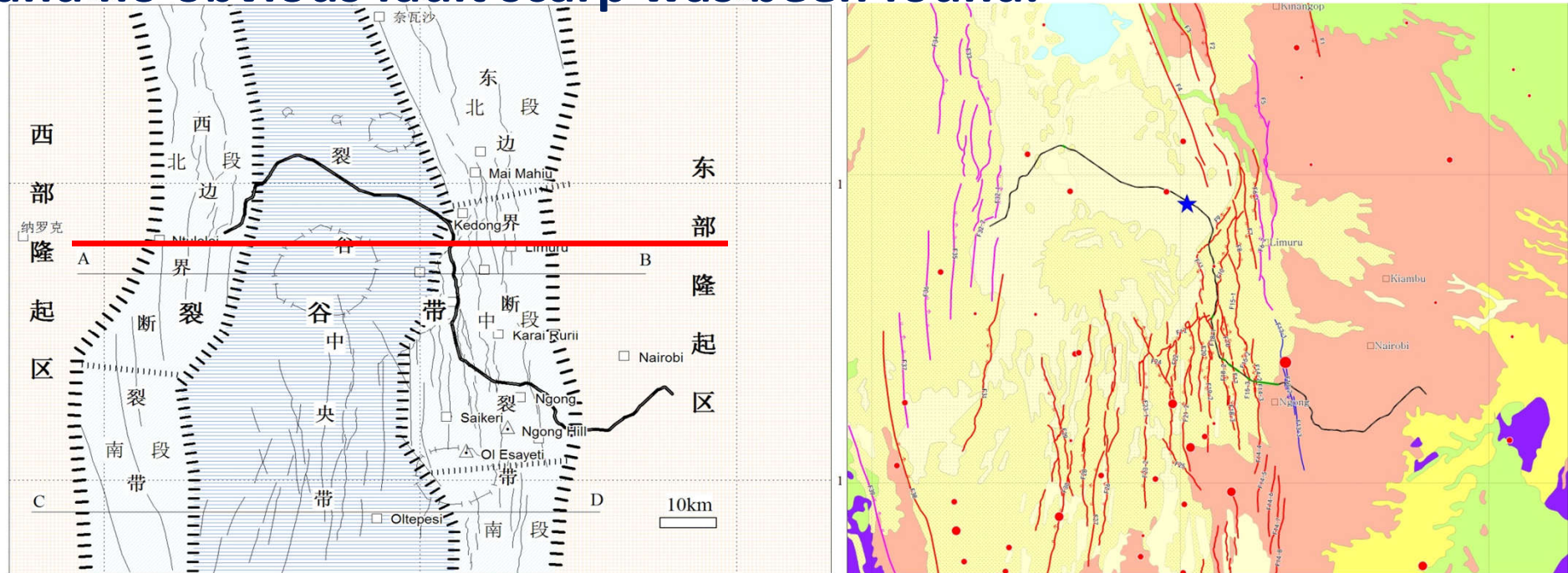
The dip of the all earth fissure was really steep (mostly vertical), with horizontal crack and vertical collapse mainly, and the vertical displacement is very small.



Drilling revealed that earth fissure plane was straight and the filling is like a plate.



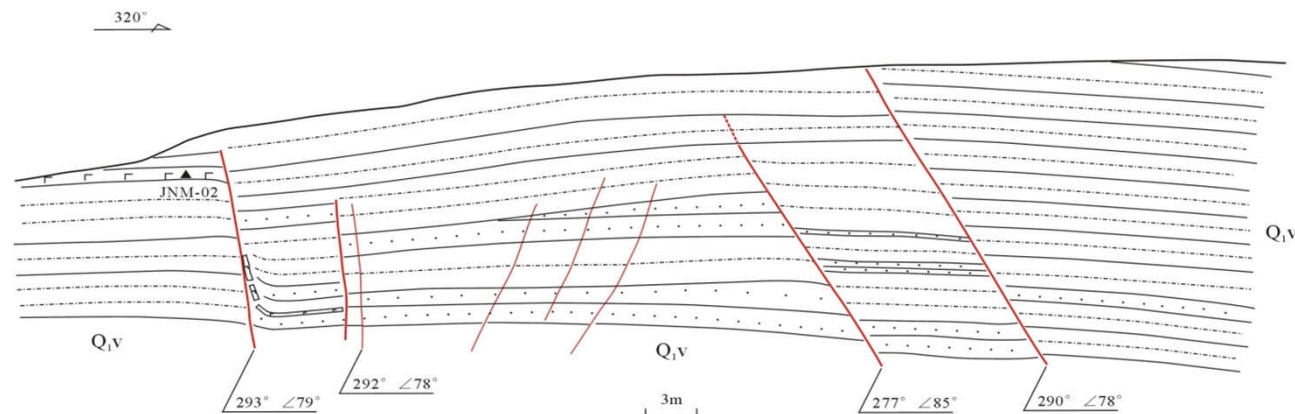
The faults on both shoulder of the rift are very developed, while in the central zone of the rift valley, the landscape is really level, and no obvious fault scarp was been found.



The eastern boundary fault is mostly Holocene fault



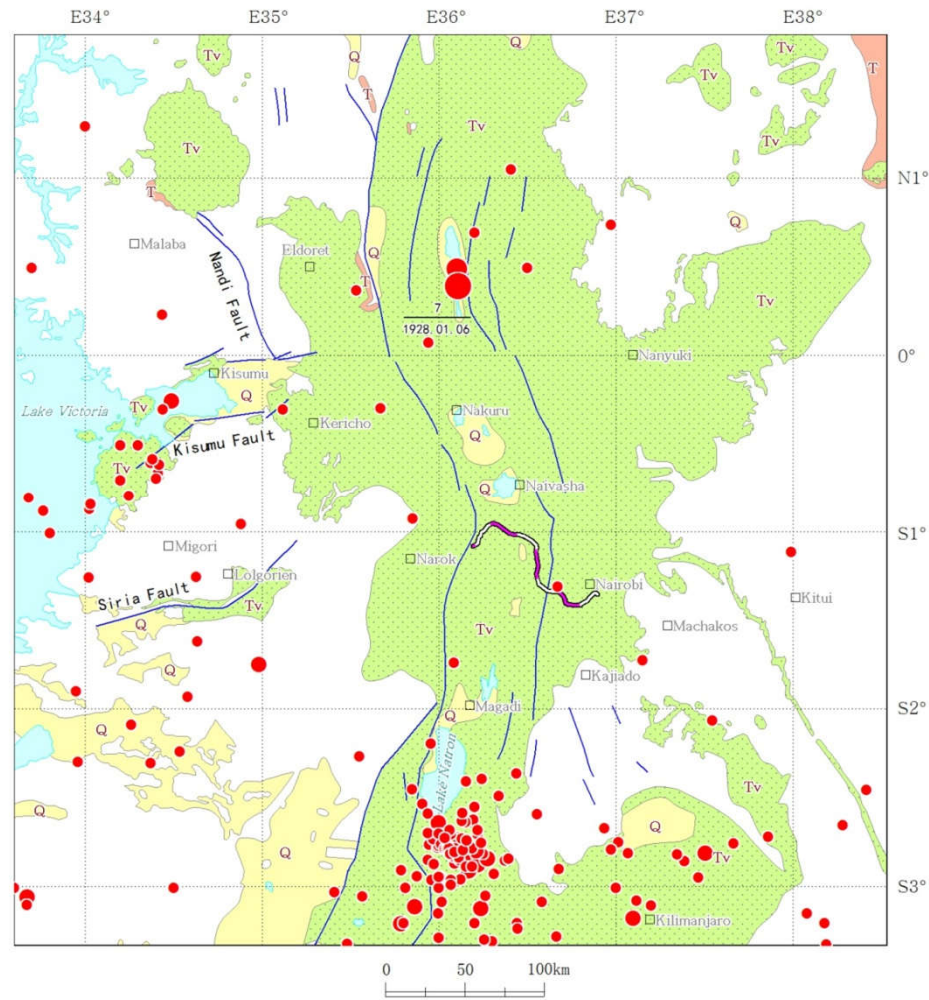
The western boundary fault is also really developed, but there is no offset in Holocene deposit, which should be late-Pleistocene fault.



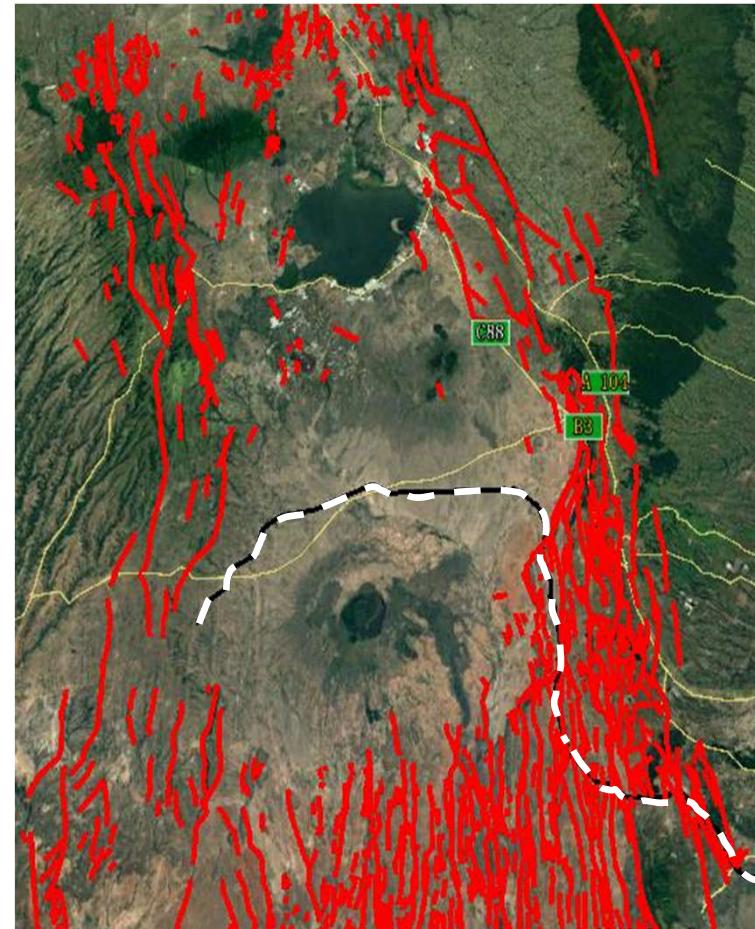
The earth fissure was developed in the central of Rift valley



Seismicity



Fault map of Rift area



Volcano



There are also two volcano on both sides of the railway line, the Longonot and Suswa volcanoes, of which the Suswa volcano now is quite, but around the crater 30 dozens of volcanic holes occasionally gas out. Longonot is an active volcano and has been one eruption in past 200 years.



Formation mechanism of earth fissure in East Africa Rift:

- 1. Effects of increasing tension in the Rift valley ?**
- 2. Response to volcanic activity in the Rift valley ?**
- 3. Results of heavy rainfall erosion and collapse ?**

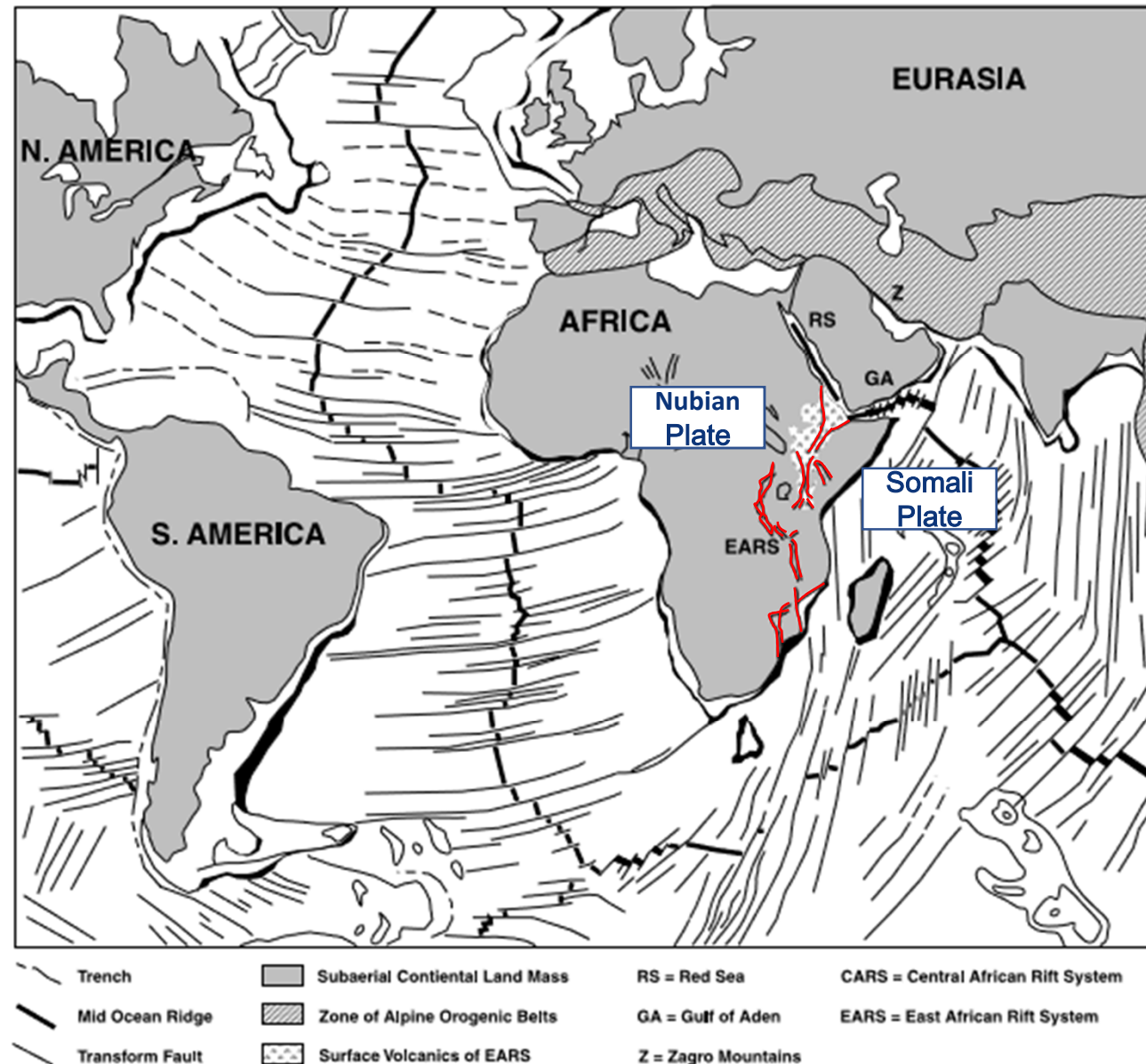
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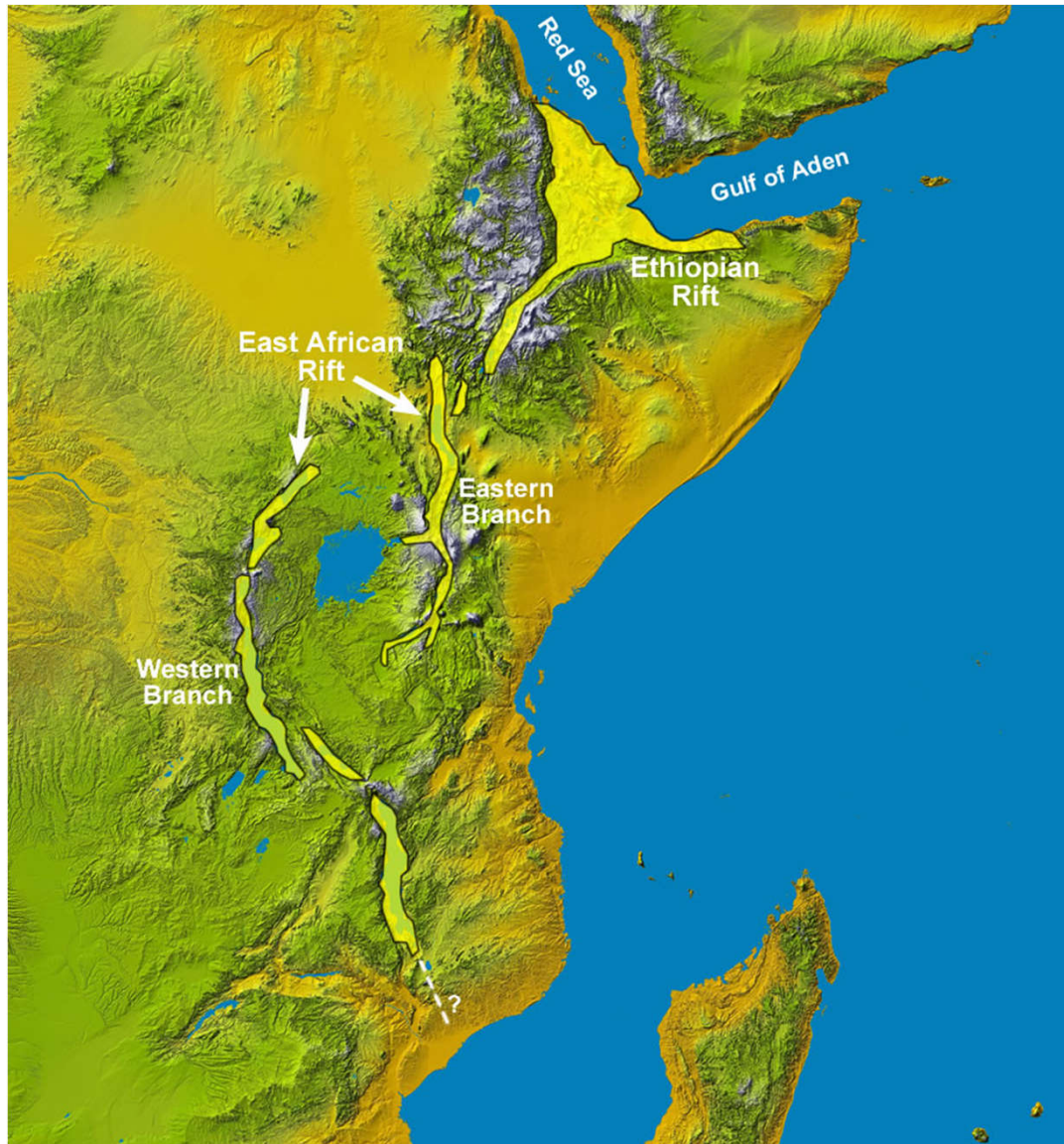
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2. Tectonic features and continental dynamics background of eastern Africa Rift

The East African Rift (EAR) is an active continental rift zone in East Africa. The rift is a narrow zone that is a developing divergent tectonic plate boundary, where the African Plate is in the process of splitting into two tectonic plates, called the Somali Plate and the Nubian Plate.



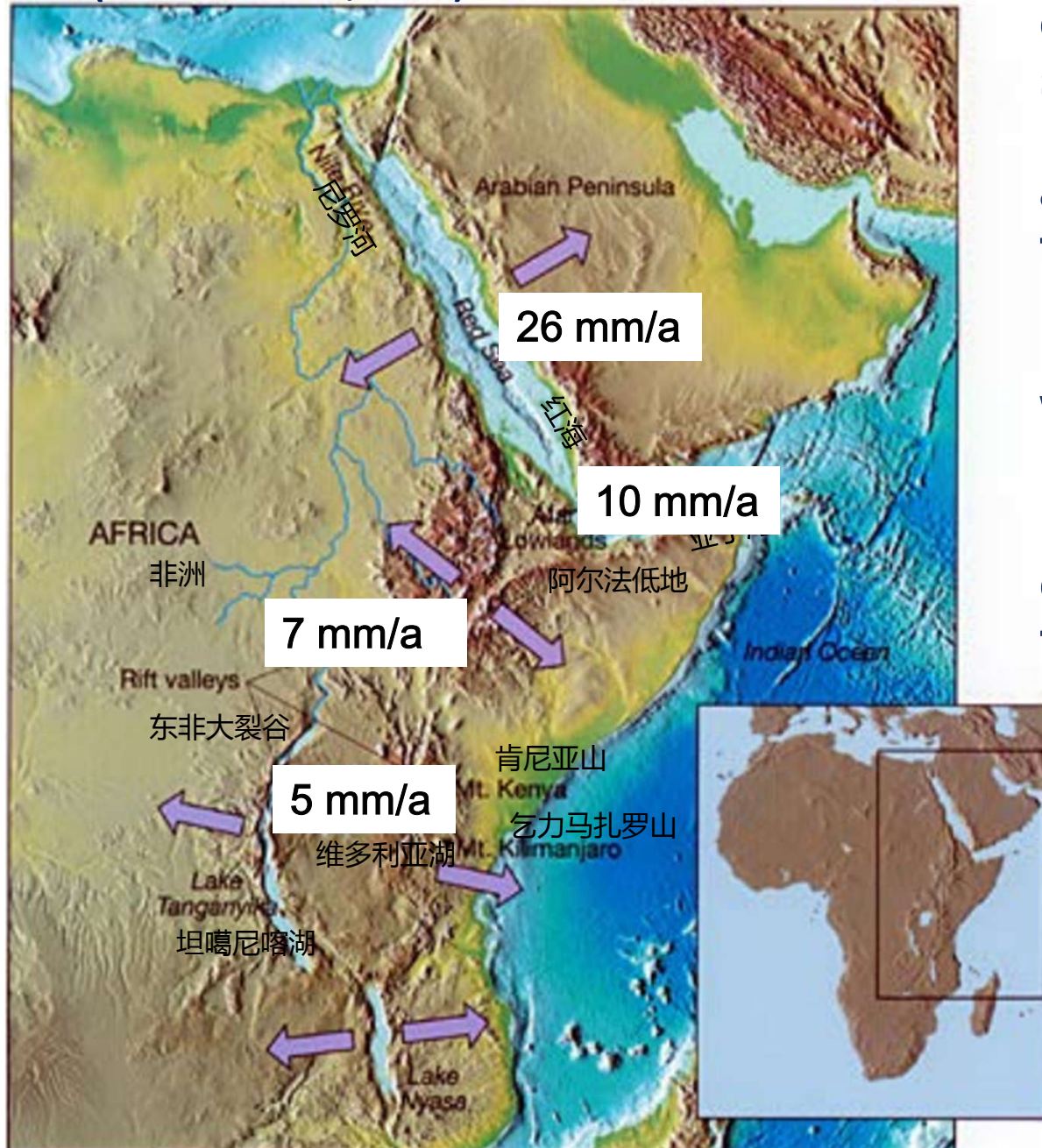


The oldest and best defined rift occurs in the **Afar region**.

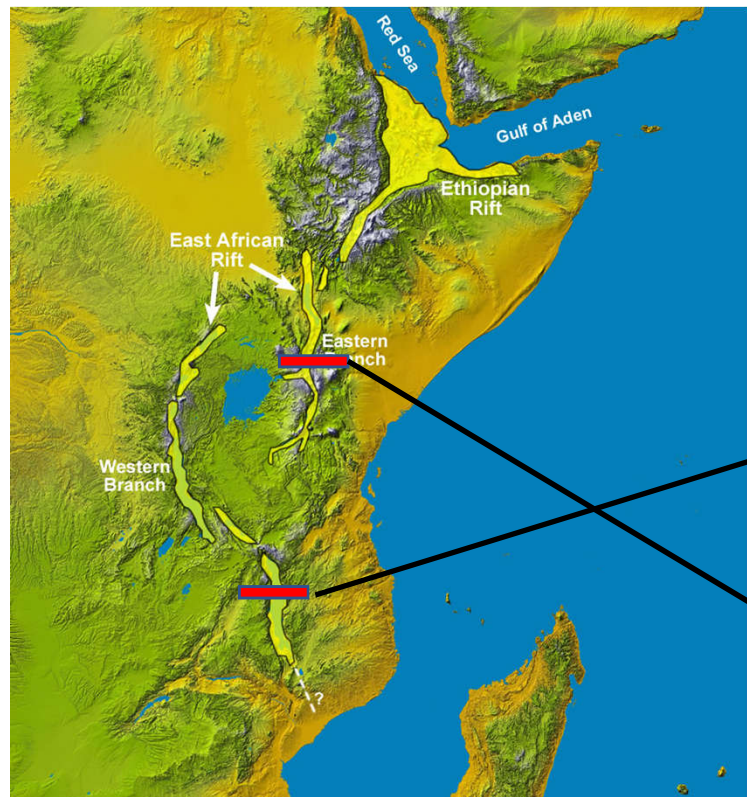
Further to the South a series of rifts occur which include a **Western branch**, and an **Eastern branch** that roughly bisects Kenya north-to-south.

The complete rift system therefore extends 1000's of kilometers in Africa alone and several 1000 more if we include the Red Sea and Gulf of Aden as extensions.

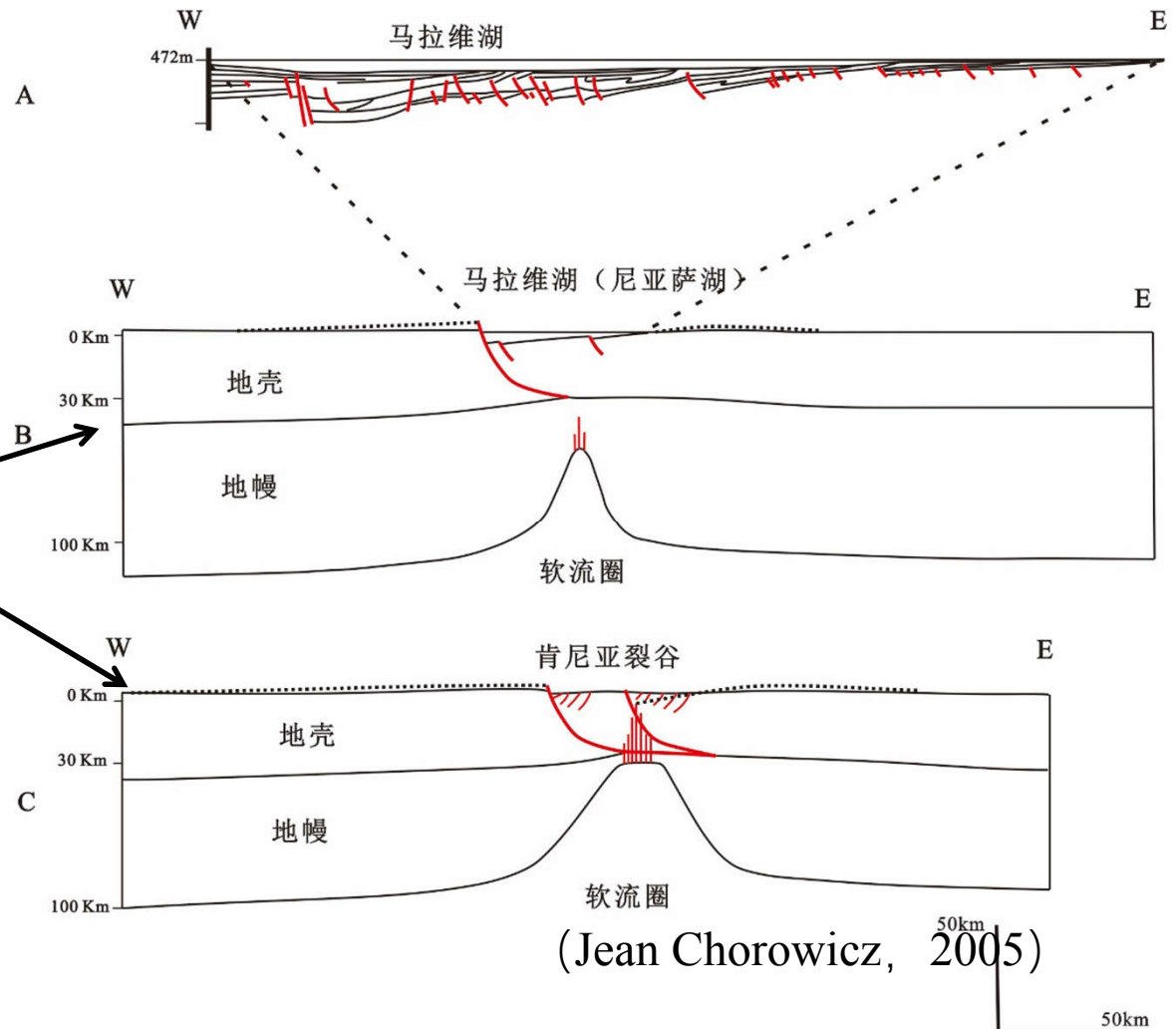
Spreading rates along the EARS decrease from north to south (Saemundsson, 2008)



Spreading in the EARS decrease from north to south from about **26 mm/a** in the Red Sea to about **10 mm/a** in Afar to **7 mm/yr** in the Ethiopian Rift and **5 mm/yr** combined in the Western and Eastern rifts across the Kenya Dome and gradually decreasing from there to the south



Seismic reflection profile of EARS



1. The rift consequently is asymmetric in the crust and symmetric in the lithospheric mantle.
2. Major listric faults bordering the one side, while on the other side the boundary fault is simply one of the many smaller faults.

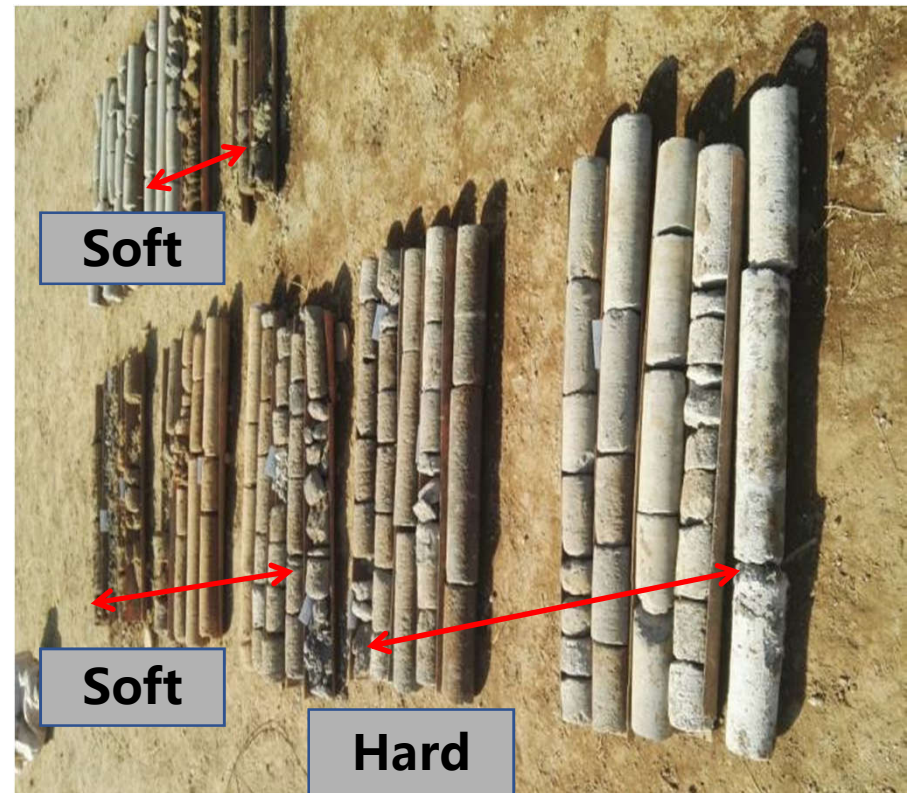
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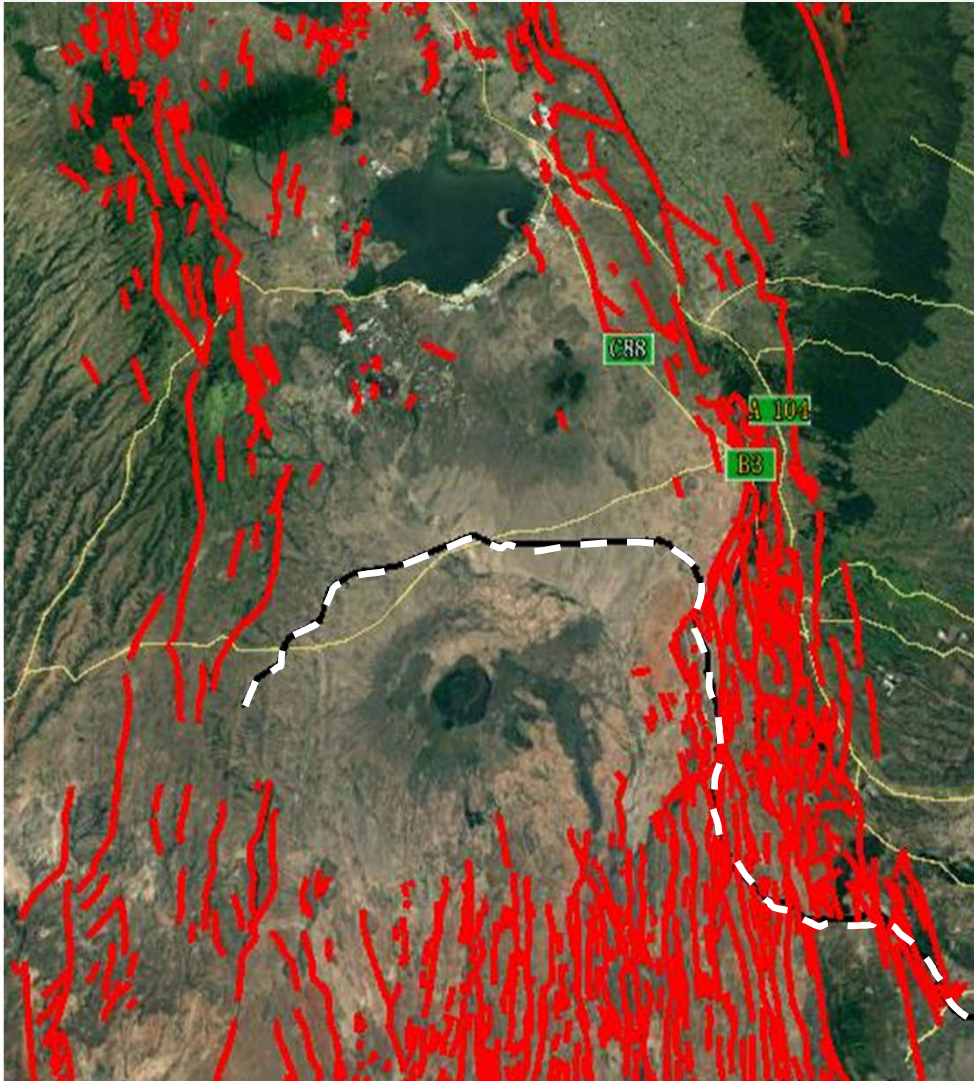
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Special geological conditions for the development of earth fissure.

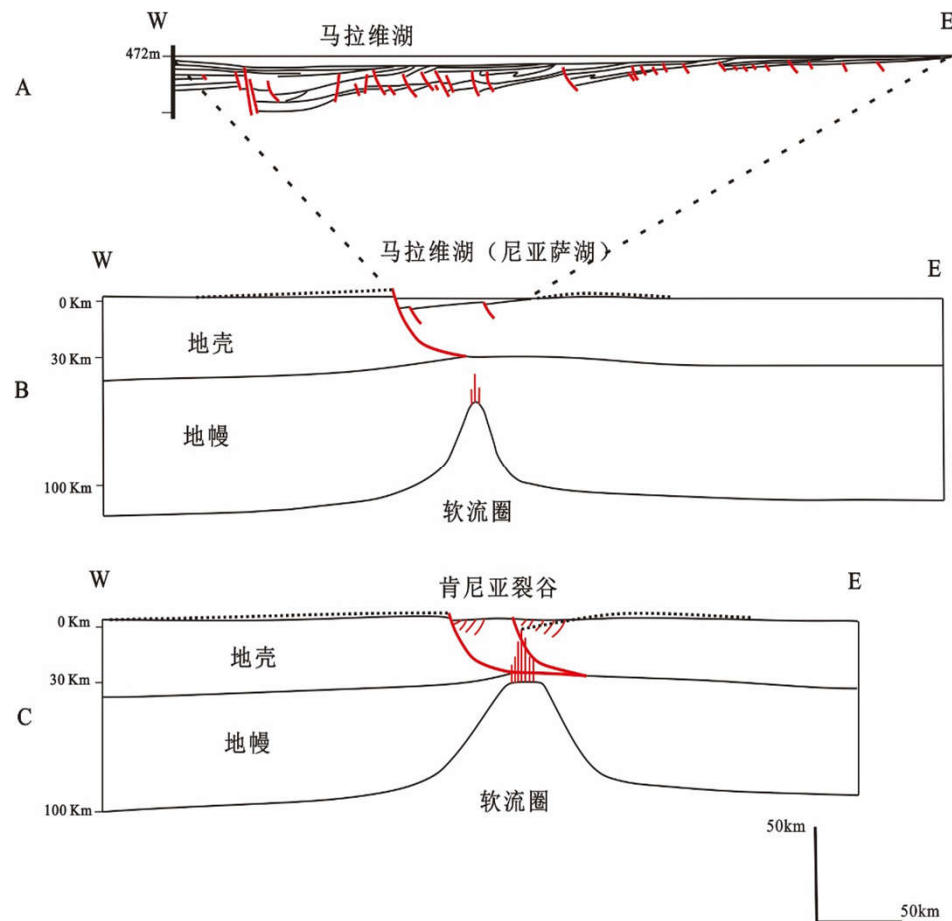
1. The shallow stratigraphic structure in the rift valley is characterized by soft upper part, hard middle part and soft lower part (like a sandwich). The upper soft soil layer is easily eroded and collapsed. The middle bedrock has tensile fracture and the underlying soil formation is easy to form an erosion cavity, which provides special geological conditions for the formation of earth fissure.



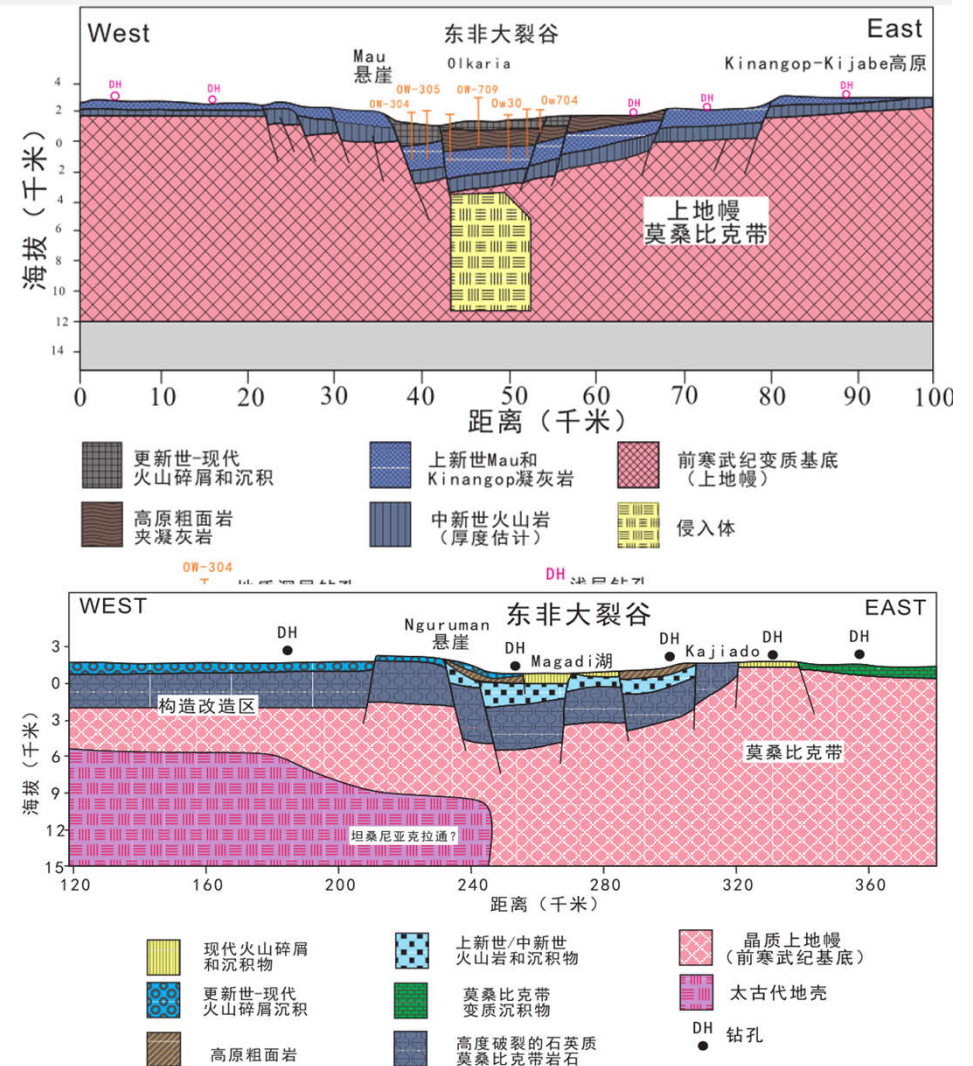
2. The Holocene active faults in the rift valley are very developed, forming part of the prototype of the earth fissure, but mostly covered by Quaternary volcanic ash.



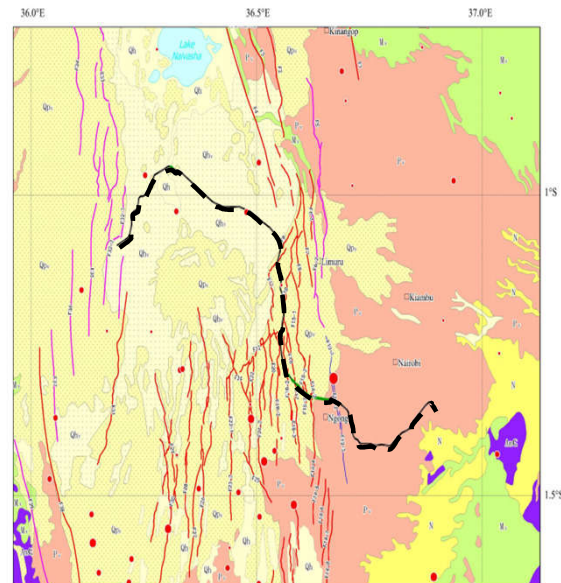
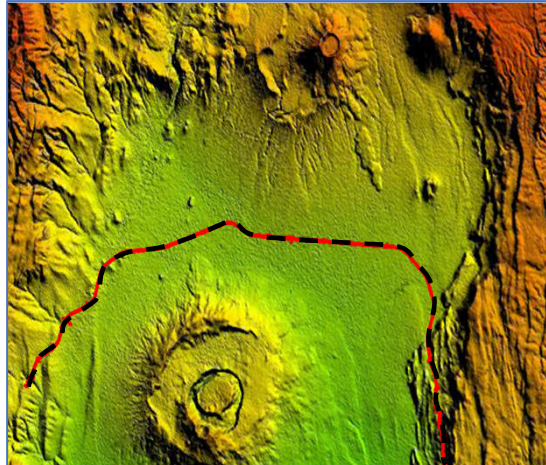
3. Crustal fault are very developed, and the shallow layer ruptures greatly, which provides deep structural conditions for the development of the earth fissure.



(Jean Chorowicz, 2005)



4. Fracture zones in bedrock are well developed, which provide structural condition for formation of earth fissure.



One trench reveal the earth fissure of the **past**, **present** and **future**.

5. The surface water flow is really few, and the all rivers are temporary channels, which may indicates that the infiltration of surface water is serious.



6. The geothermal gas is spilling out from part earth fissure, the composition analysis shows that there is a mixture of deep material in the crust.



■ **Gas sample :**

The CO₂ content in the gas is significantly higher (1.05-1.76%) than that in the air (0.03%), indicating that the gas may have come from deep crust.

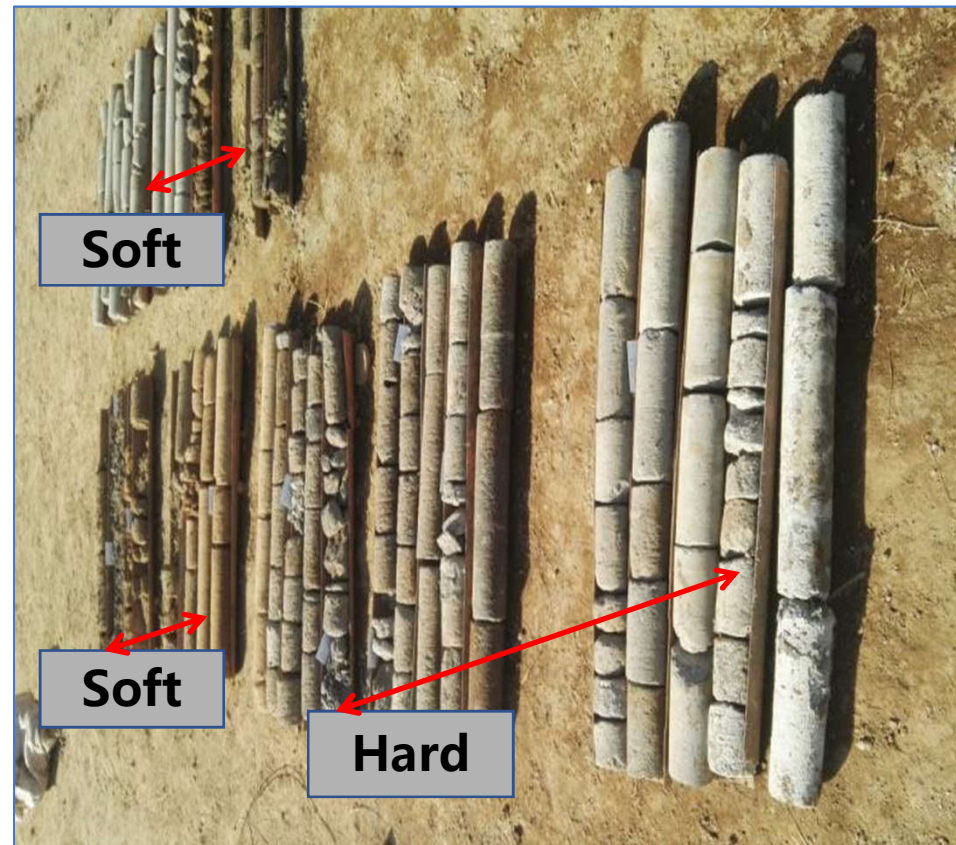
■ **Helium(He) isotope data show that the gas rising along the earth fissure is a mixture of crust material and mantle, of which the proportion of crust gas is about 80%, mantle gas is about 20%.**

7. Layer of surface volcanic ash is really soft and is liable to erosion and collapse to form earth fissures.

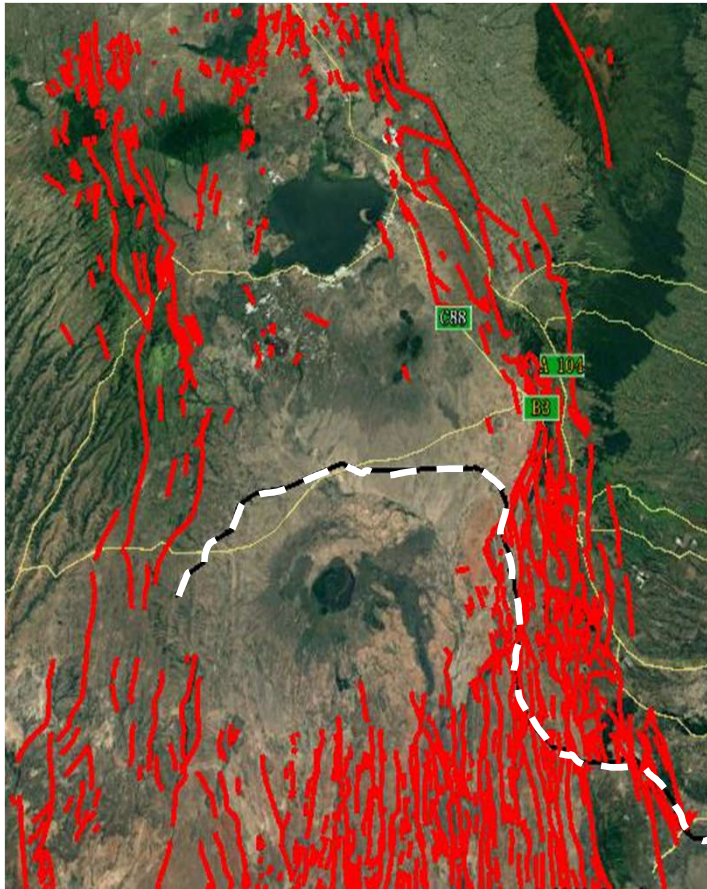


The mechanism of formation of earth fissure in Kenya Rift

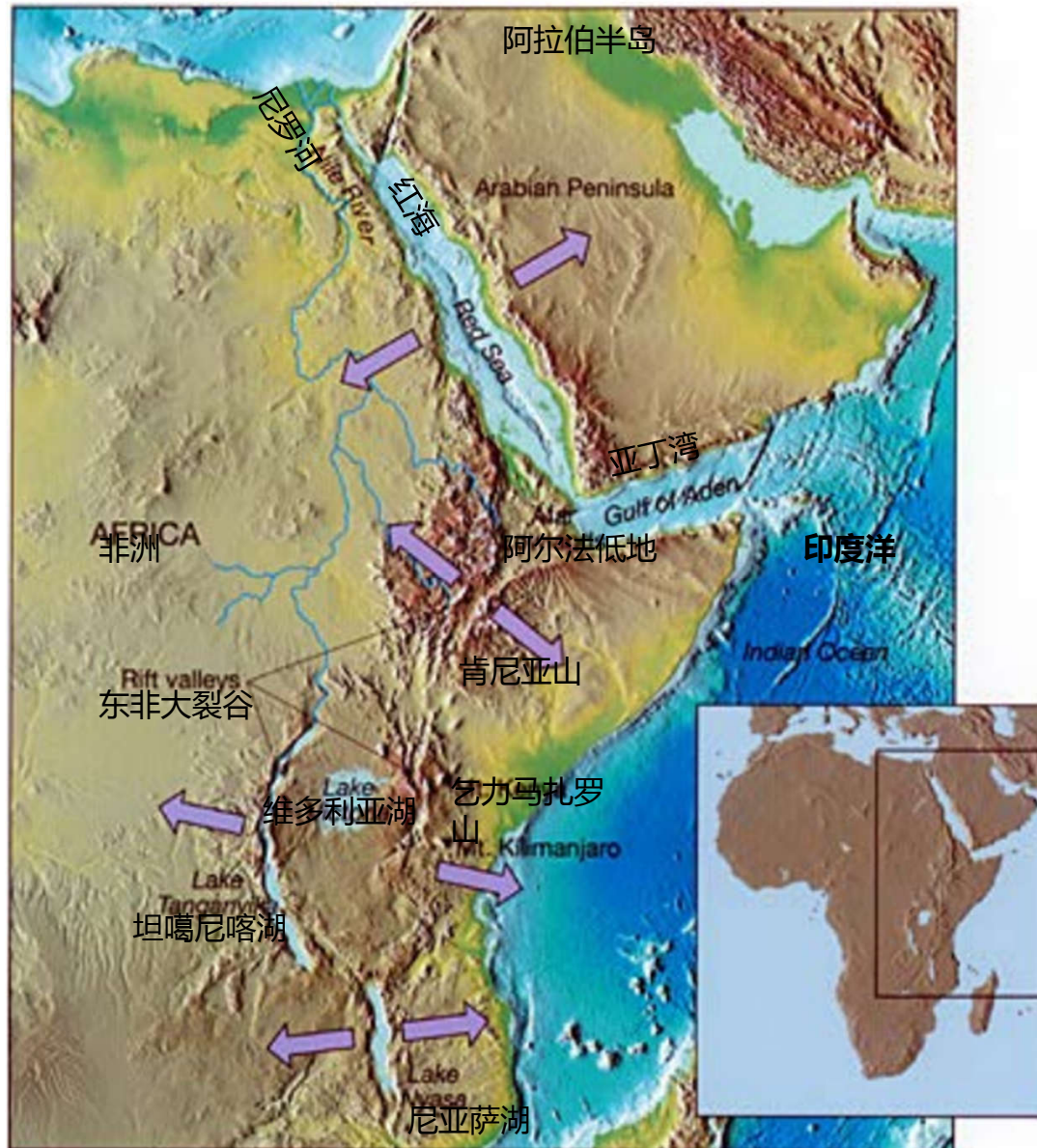
1. Special stratigraphic structure provides favorable conditions for the formation of earth fissure.



2. Various types of structural fractures control the location of the spatial output of earth fissure.

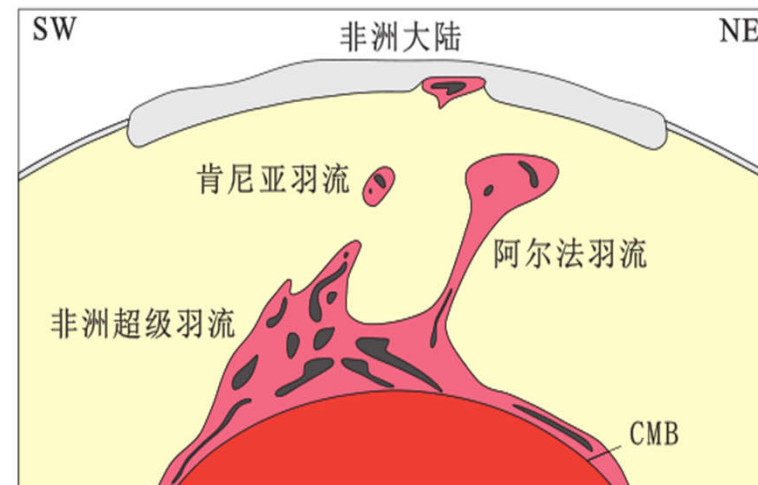
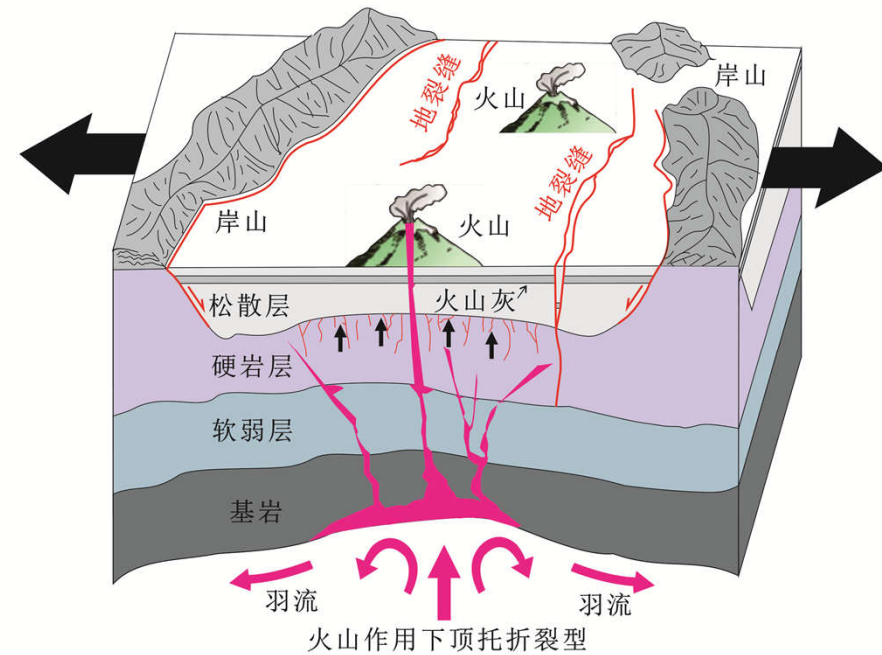


3. Lateral movement of Kenya rift provides horizontal driving force for the formation of earth fissure.

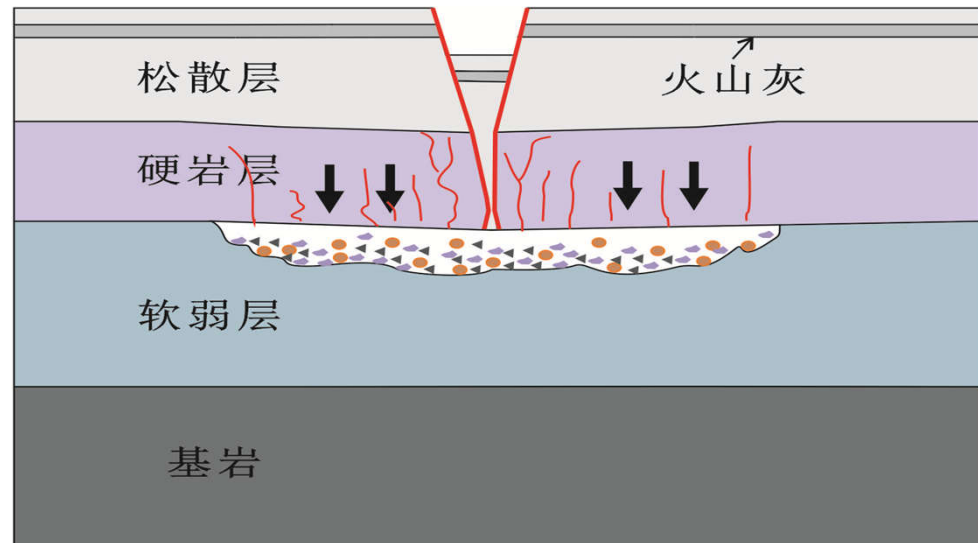


(Björn S. Hardarson, 2015)

5. The magmatic process of the mantle provides deep driving force for the formation of ground fissures.



6. Heavy rainfall erosion causes earth fissure that appear on the surface.



重力作用下硬岩弯裂型

The mechanism of formation of earth fissure in Kenya Rift

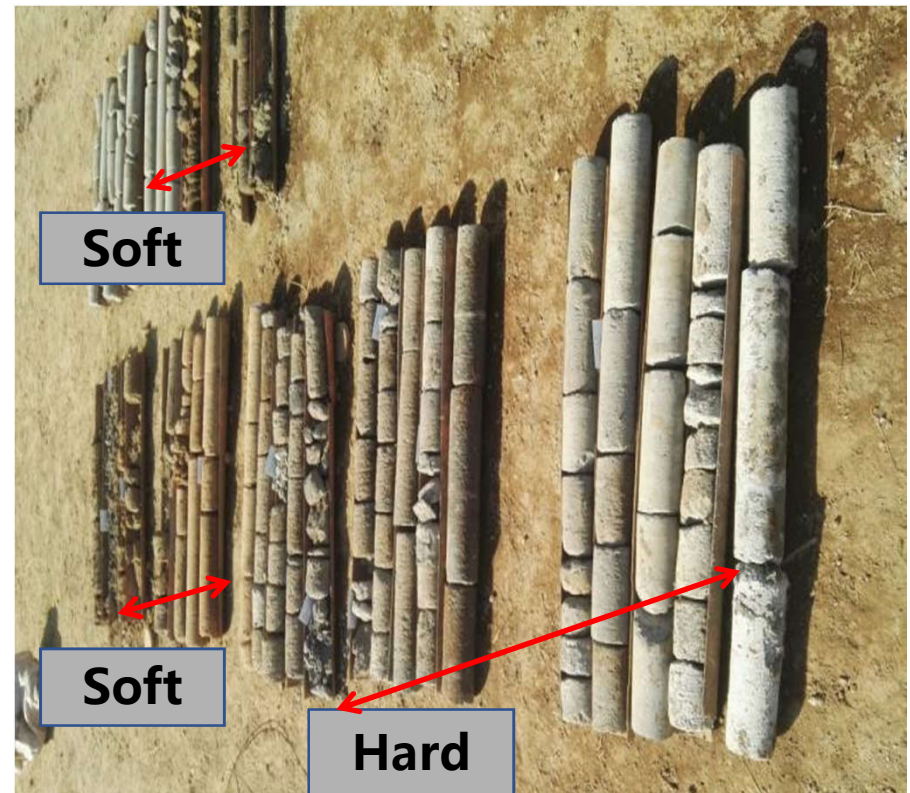
Structural control

Stress forming

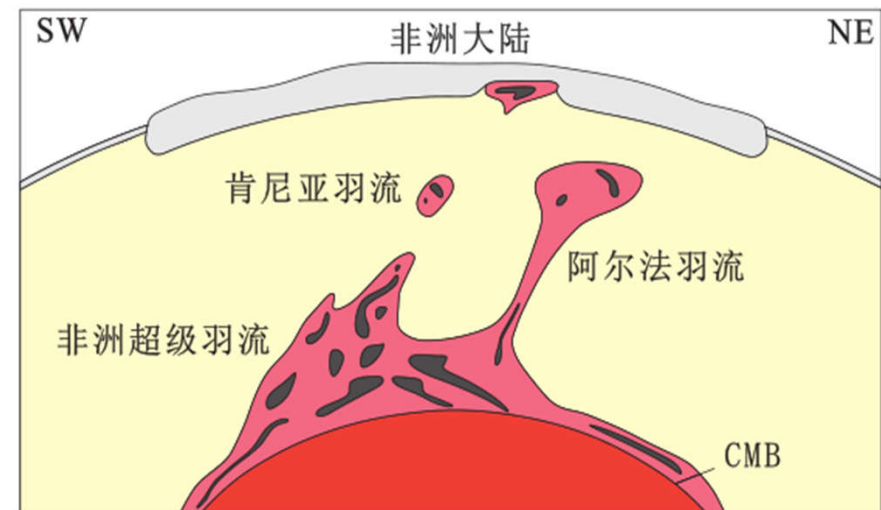
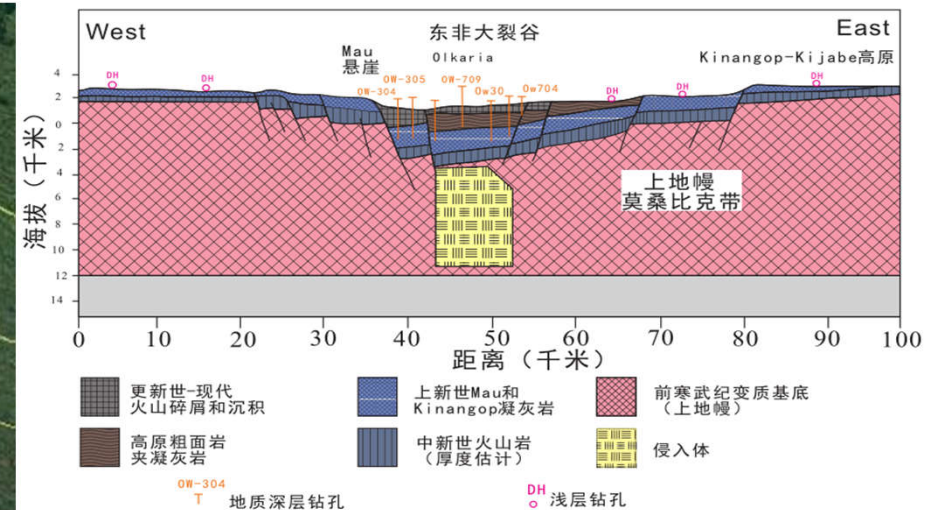
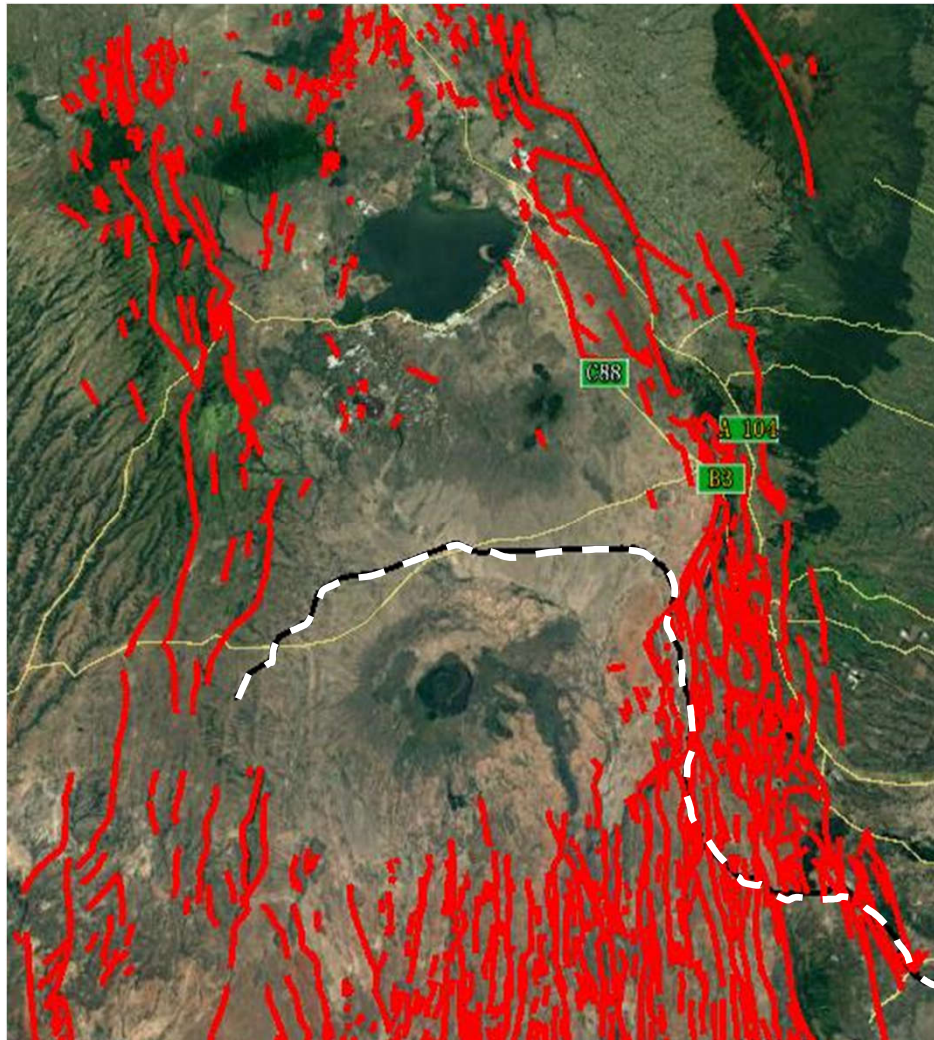
Water spreading

Significant scientific problems concerning the mechanism of earth fissure still need to be solved.

1. How does the structure of the sandwich layer affect the formation of earth fissure?



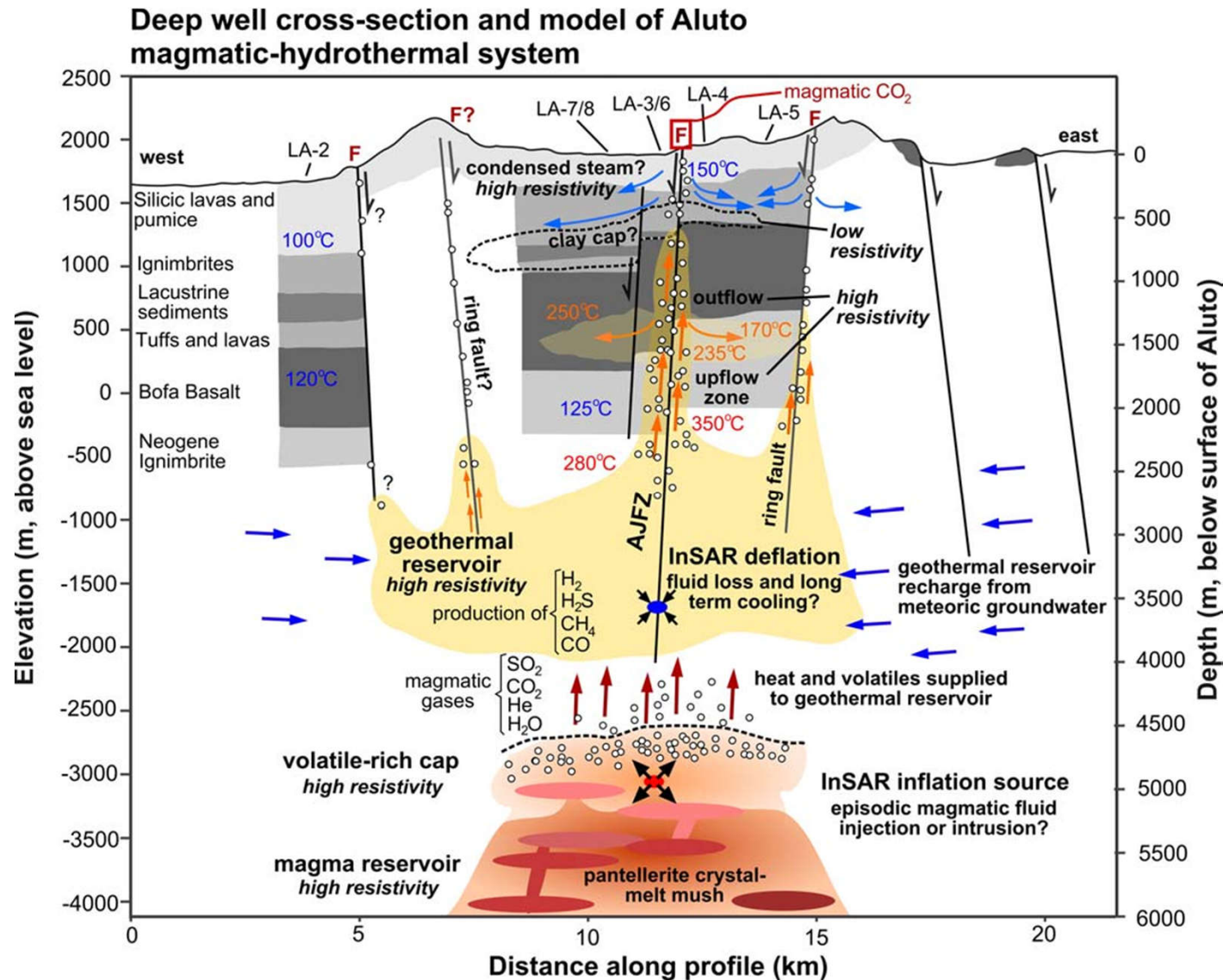
2. What is the relationship between the formation of fault structure and volcanic activity?



3. Is there a correlation between volcanic activity and the spatial distribution of bedrock rupture and does the bedrock rupture have different periods?



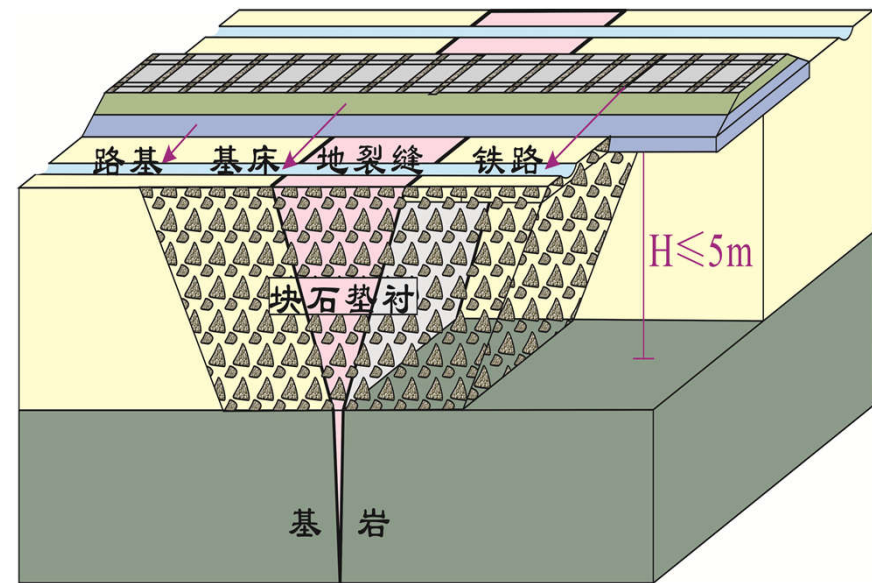
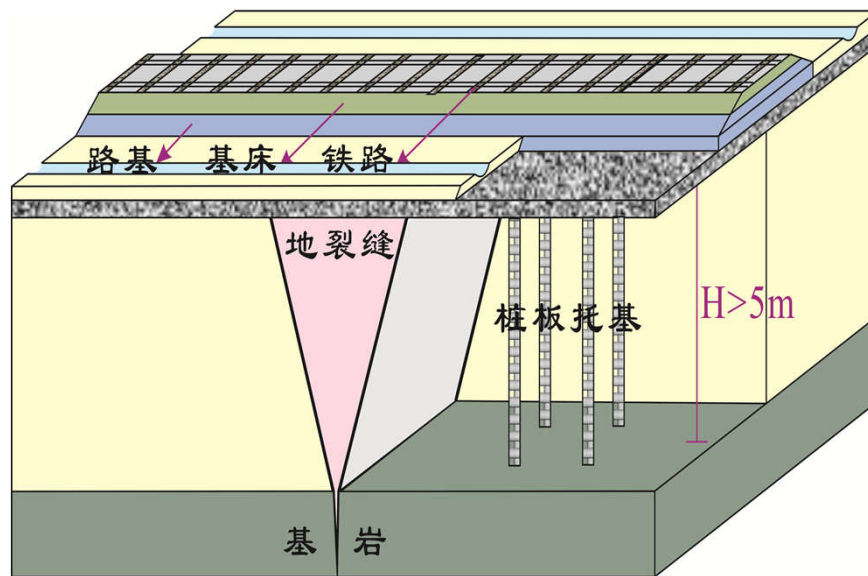
4. The gas samples show a mixture of mantle material, so how is the earth fissure connected to a deep and large fault in the crust?



6. How does surface water interact with groundwater, and what is the quantitative relationship between the water cycle and the expansion of earth fissure.



7. How to cross the active zone of earth fissure safely in railway engineering?

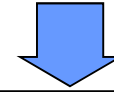


Fenwei Basin VS

EARS



Spreading rate
2mm/a



Spreading rate
5mm/a

Crustal thickness
35km

Crustal thickness
30km

Normal fault
control

Fault and bedrock
crack control

Little activity of
deep thermal
event

Deep thermal activity
is significant and
connected to the
surface.

Pumping water
causes earth
fissure to extend

Surface water
seepage causes earth
fissure to extend