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# Pedogenetic Effects in Fault Evolution

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## SUMMARY

During the late Oligocene - middle Miocene, an extensive deformation took place in the Western Mediterranean. In this process, main faults of NE-SW striking direction bordering horsts and grabens of the Catalan margin and minor faults perpendicular to the former were formed. We have studied some of these minor faults affecting Miocene conglomerates in the Barcelona Plain. The fault zone is formed by an absent damage zone and a poorly developed fault core. Their fault rocks are obliterated by later pedogenetic processes that have changed fault and fault rock properties and consequently fault rock classification. Nowadays fault rock is a cataclasite but because it is cemented by later pedogenetic processes, in fact, in origin was a gouge. When fault rock was a gouge (stage 1), and considering fault zone architecture, cross-fault flow could exist. During the second stage, after fault rock pedogenesi, new minerals reduced effective porosity and so permeability of the fault rock. The consequence was the seal of faults and compartmentalisation of flow. In conclusion, faults occurring in the upper meteoric environment can have other kind of processes responsible of their impermeabilization than deeper faults.

INTRODUCTION

Behaviour of faults respect to fluid flow depends on fault zone architecture. Depending on which is the relation about fault core and damage zone, they act as barriers or conduits for fluids (Caine et al. 1996; Rowland and Sibson, 2004). However, we have observed that other processes apart from tectonics can seal faults. This paper deals with minor normal NW-SE and N-S striking faults affecting Miocene conglomerates within the Barcelona Plain which fault rocks have been obliterated by later pedogenetic processes. These faults are perpendicular to the main faults bordering the horsts and grabens that form the Catalan Coastal Ranges, which have a NE-SW striking direction (fig.1). All these faults are related with the Neogene extension (late Oligocene-middle Miocene) that took place in the Western Mediterranean.

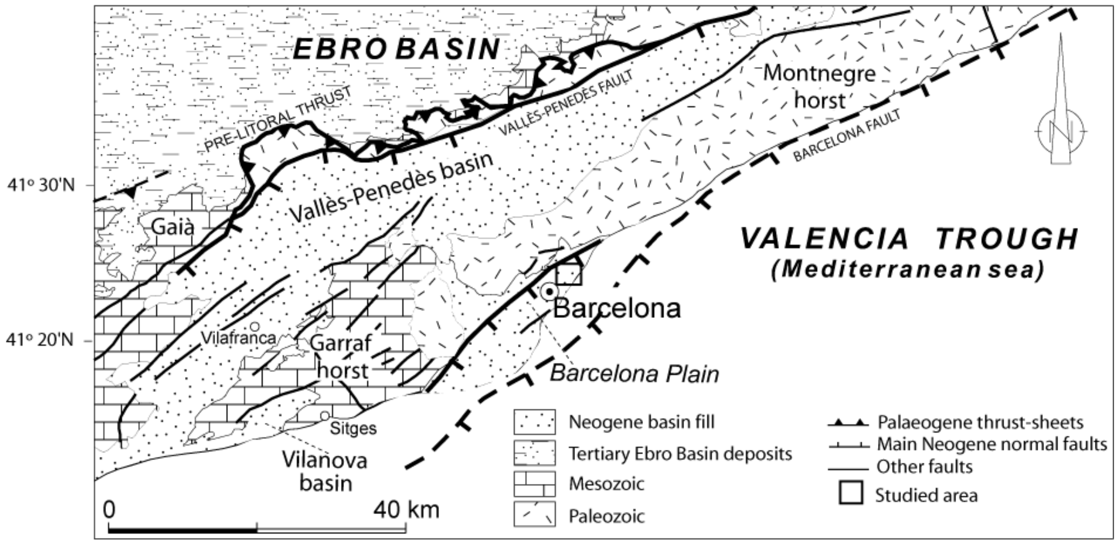

***Figure 1*** *Geological setting of the studied area.*

RESULTS

Conglomerates constituting the host rock of the studied faults are interpreted as deposited in alluvial fans. Conglomerates are formed by a reddish mud-to-sandy matrix and heterometric paleozoic clasts and have mud-to-sandy lentils interlayered.
Fault zone in these Miocene conglomerates has a poorly developed fault core (from absent to 7 cm width) as narrow discrete bands and an absent damage zone. Fault rocks consist in a cohesive, reddish mud-to-sandy material with clast volume under 30%. For these reasons they have been classified as cataclasites (Sibson, 1977). However, the petrological study has revealed that cohesiveness is given by later pedogenetic processes. The main pedogenetic products are orange bladed crystals of calcite that form two kinds of aggregates: spherulites and palisades. This fact has a strong impact in fault rock classification because probably the original fault rock was uncohesive and so it was a gouge. Pedogenetic products, which form in the upper meteoric environment, imply that at least part of the fault rock evolution took place in shallow burial conditions with meteoric fluids. This supports the initial formation of a gouge because it is formed in shallower conditions than the cataclasite interpreted firstly.
Pedogenetic processes affecting the fault rock produced important changes within the fault rock in front of fluids which can be summarized in two stages.
The first stage took place just after the formation of the faults (fig.2a). Fault zone, as described before, was formed by an absent damage zone and an absent to poorly developed fault core that in this stage was formed by a gouge. Besides, the host rock is a sedimentary deposit with layers of different permeability (more conglomeratic layers are more permeable than the mud-to-sandy lentils). This architecture and the relative differences in permeability of the different layers of the host rock and the fault rock allowed a cross-fault flow when permeable layers were juxtaposed (Rowland and Sibson, 2004). If not, juxtaposition seal took

place and a partial compartmentalisation occurred. So at this stage, faults acted as localized conduits (Caine et al. 1996).

The second stage started after the formation of the pedogenetic products. Fault zone architecture and host rock characteristics were the same as in stage one but fault rock had changed its properties. Now, a cemented fault rock constituted the fault core and not a porous gouge (fig.2b). The growth of the pedogenetic minerals reduced the effective porosity producing an increase of fault rock impermeability sealing the fault. The result was that faults acted as barriers. In this stage, there was a compartmentalised fluid flow.

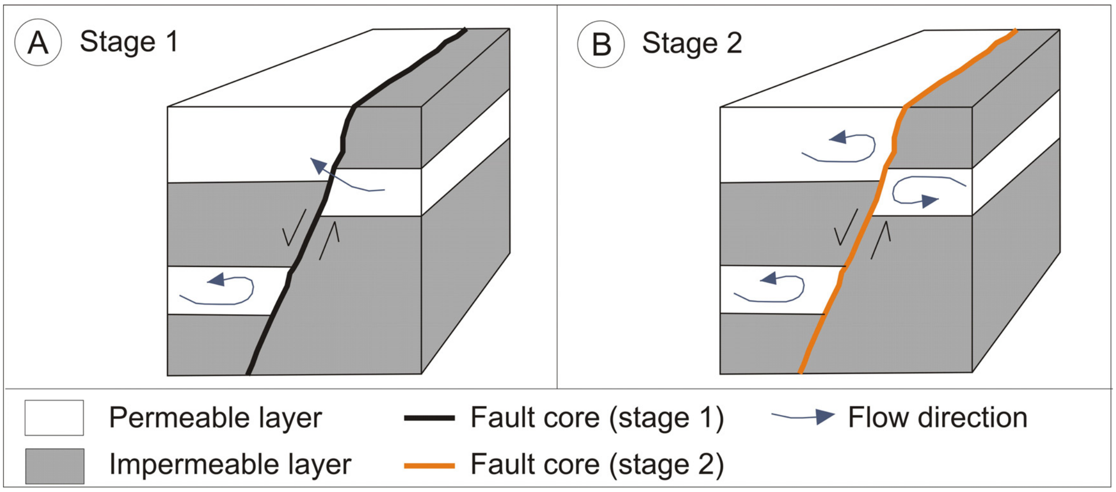


***Figure 2*** *Fluid flow in the minor normal faults. A) Stage 1: fault core is a gouge. B) Stage 2: fault core is impermeabilized by pedogenetic processes (Modified from Rowland and Sibson, 2004).*

CONCLUSIONS

Minor faults affecting Miocene conglomerates of the Barcelona Plain have two stages with different fluid flow behaviours during the Neogene extension. These stages are caused by the diagenetic evolution of their fault rocks. In the first stage, faults acted as localized conduits and cross-fault flow could occur between the juxtaposed permeable units. During the second stage, after the formation of the diagenetic products in the fault rocks, permeability of the fault core was reduced and faults acted as barriers.

In conclusion, faults occurring, partially or totally, in surface conditions within the meteoric environment, can have other kind of processes responsible of their impermeabilization than deeper faults.

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