# FLUID INCLUSION PLANES: A LINK BETWEEN FLUID FLOW AND BRITTLE DEFORMATION IN SPACE AND TIME !

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Most fluid migrations in rocks are favoured by fissure permeability which forms during brittle deformation. The deformation is in some instances related to fluid pressure and movement of faults. Evidences of paleofluid migration through the fractured rock may be very scarce, whatever the observation scale. The best record of formed fluid percolation are paleofluids trapped as fluid inclusions in healed microcracks of the rock forming minerals or within the infilling of microstructures (the Fluid Inclusion Planes, **FIP**). However, the repeated microfracturing and healing of the rock forming minerals yield complex superimposed patterns of healed microcracks. Such patterns are often difficult to interpret due to the lack of suitable chronological criteria. These problems can be documented and solved by coupling deformation studies, detailed examination at all scales of the relationships between trapped fluids and their host structures, and studies of fluid inclusions.

## FIP and brittle deformation

The FIP results from the healing of former open cracks and appear to be fossilized fluid pathways (review in Roedder, 1984). FIP are mode I cracks and should provide valuable information about the local stress in rocks (Lespinasse and Cathelineau, 1995) and can be assimiled as ($\sigma 1$ - $\sigma 2$) planes (Tuttle, 1949; Boullier, 1999; Lespinasse and Pêcher, 1986; Lespinasse, 1999). These mode I cracks are propagating in the direction which favors the maximal decrease of total energy of the system (Gueguen and Palciauskas, 1992). They do not disrupt the mechanical continuity of mineral grains and do not exhibit evidences of displacement contrarly to the mode II and III. The FIP are mainly characterized in minerals from which cristals may crack according to the regional stress field, independently of their cristallographic properties (Lespinasse and Cathelineau, 1990), and may easily trap fluids as fluid inclusions when healing (Pecher et al., 1985). In other minerals (carbonates, feldspars), the fluids are not always preserved from further disturbances and cracks display more complex patterns resulting from the presence of easy cleavages, subgrain boundaries or twin planes. The rate of healing is short in quartz (compared to geological times) as shown by Brantley (1992). Frequently FIP form well defined networks which permitt an elaboration of a chronology.

## FIP and fluid flow

A chemical composition of the fluids can be related to each FIP family. After a first generation of FIP formation (and fluid migration), another crack family can be formed with trapping of a second fluid . This second generation of FIP crosscut generaly the first one (figure 1).

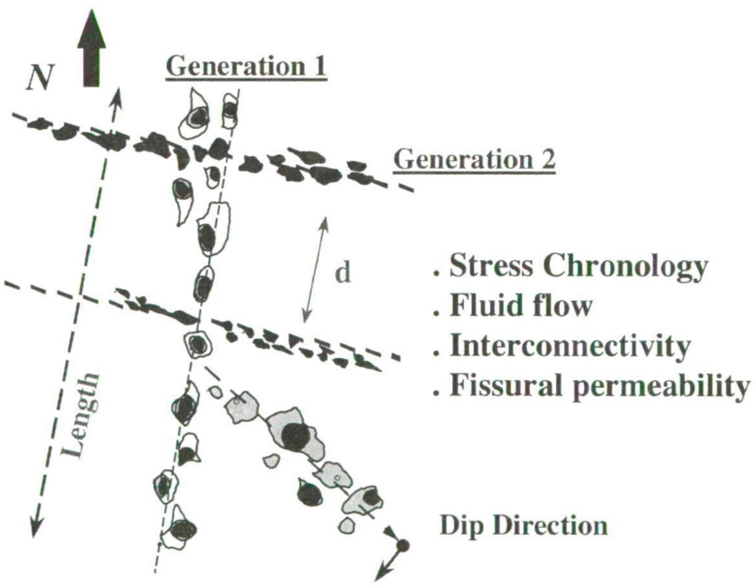


Figure 1: Fluid Inclusion Planes: a link between fluid flow and brittle deformation in space and time !

Thus, one can admitt that the FIP are good records of successive episods of crack initiation (related to local stresses) and fluid migration (with a specific chemical composition). Each FIP family can be characterized with a mean length , surfasic density (see abstract from Desindes et al.) and aperture. Then , quantification of fissural porosity and permeability can be easily obtained.

**Conclusion**

FIP permitt a detailed reconstructions of the links between strain, chemical composition of the fluid, thermicity and fluid flow in rocks (matrix permeability) in the same sample and as a function of time.

**FIP can be considered as an excellent tool for "Rock Memory" reconstruction.**

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