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Fluid migration through fracture networks, Gale crater (Mars)

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The Curiosity rover's campaign in the Gale crater on Mars provides a large set of close-up images of sedimentary formations outcrops displaying a variety of diagenetic features such as light-toned veins, nodules and raised ridges, subsequent to burial and consolidation of the sediments. The purpose of this study is to assess the structural behaviour recorded by a well exposed crack system filled with light-toned materials in a case study area along the rover traverse. To investigate such vein system observed between sol 1536 and 1545, we analysed MastCam and NavCam images coupling 2D mosaics and the production of a 3D photogrammetric model of the same region in order to extract the structural information and reconstruct the fracture distribution in the area of interest covering ∼100 m2. Observations allowed to identify the presence of one population of sub-horizontal sub-parallel light-toned veins and a second population of middle to high-angle dipping light-toned veins, all of them displaying a higher resistance to erosion with respect to the host rock, so sticking out from the outcrops leading to an easy identification. Overall, a regime of extension is deduced from the oblique vein network that shows two cross-cutting sets which intersect at angles of ∼60° and show en-echelon structures displaying shear sense that led to a lowering of the hanging wall. Accordingly, the maximum principal stress is suggested to bisects the acute angle occurring between the sets, that in the specificity of this case would mean that $\sigma 1$ lays on a sub-vertical axis. The horizontal stresses $\sigma 2$ and $\sigma 3$ orientations have a slightly wandering direction trend. Fracture strike direction can vary on a range in stress fields where $\sigma 2$ and $\sigma 3$ could be equal or similar which is a reasonable scenario in a closed sedimentary basin, where the even horizontal constraint is the crater lateral confinement. The second cracking system drive that generated the horizontal network can be ascribed to hydrofracturing. This can be triggered either by the emplacement of an overburden that perturbs fluid pressure and initiates fluid buoyancy, or as response to an unloading event when pressurized fluids are already stored in the subsurface. The origin of fluids at Gale is still debated and overpressure cracking itself does not carry enough information to discriminate it. Nevertheless, the evidence of a coeval genesis of the oblique and the horizontal vein networks leads to the hypothesis that a pulse of material overload within the crater could have been responsible both for the extensional failure and the fluid escape from the already consolidated deposits on the crater floor.

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