Quartz Veining in Archean Shear Zones, Abitibi (Quebec), Canada

R. Doutre*, M. Jébrak, and A. Amortegui

Département des sciences de la Terre et de l'Atmosphère, Université du Québec à Montréal, CP 8888, succursale Centre-ville, Montréal, QC H3C 3P8, Canada

*raphael.doutre@gmail.com

Summary

Major Archean shear zones or breaks are sites of high fluid circulations that are characterised by intense veining at the brittle-ductile transition. Despite the common occurrence of high degree of veining along these accidents, detailed vein geometries and spatial distributions remain poorly understood. In modern environment, veining is dependent of shear zone seismic regime and could be controlled by aftershock domains that are sites of enhanced permeability. Vein geometries and distributions could therefore be use to better understand the evolution of the permeability and hydrothermal processes during Archean time.

Introduction

The Kinojevis shear zone is the eastern extension of the Porcupine-Destor shear zone in the Abitibi greenstone belt, Quebec, Canada; it is located 40 km north from Val-d'Or. Recent boreholes and a detailed aeromagnetic survey allowed improving the organization of the geology along the shear zone; trenching permitted detailed mapping and recording of vein geometrical characteristics in different contexts inside and close to the shear zone. Measured and calculated vein parameters include thickness, length, shape ratio, spacing, density, and coefficient of variation which is a measure of vein clustering (Gillespie et al., 1999). Three sectors have been mapped, representing different style of vein development: the MacCormack and South Rambull areas both show periodic veining with lithological controls, whereas the North Rambull area veins are shear-controlled and show typical crack and seal textures (Robert and Poulsen, 2001) in a homogenous lithology.

Examples

In the MacCormack area, the shear zone is hosted by ultramafic lavas and records widespread alteration events. Multiple intrusions emplaced along the structure which exhibits a complex deformation history. The shear zone has undergone folding while veining occurred. Veins have systematic pure extension opening mode and shear-veins are absent. Vein parameters were recorded in the core and the damage zone of the fault. Results show that vein volume is far more important inside the shear zone but vein density and clustering is the same within and outside the shear zone. This indicates that the fracturing intensity was the same, leading to a similar structural permeability, but with a larger development in the core zone. Veins are unrelated to shear zone mechanism and are the result of high lithostatic overpressure leading to hydrofracturing with an absence of shear reactivation.

The South Rambull area has a heterogeneous geology with layered lithologies. Shear zones are developed in basalts at the contacts with gabbro sills. Veins are mostly confined to the gabbros acting as competent layers and are arranged in stratabound arrays. Fracturation is periodic and veining is unrelated to shear zones mechanism.

The North Rambull area shows a shear zone developed in a homogeneous granitoid body. Shear veins are widely developed and are hosted by principal and secondary shears. The crack and seal vein textures show that the fault valve behaviour was the dominant mechanism for vein formation (Sibson et al., 1988).

Discussion and Conclusions

The three sectors display different veining types along the same shear zone. Vein-related gold mineralization is well developed in the North Rambull sector and poor to inexistent in South Rambull and MacCormack sectors. In North Rambull, quartz veining appears to be related to the Sibsonian fault valve mechanism (Sibson et al., 1988). Although similar intensive veining occurs in MacCormack and South Rambull, shear veins are absent. In South Rambull area, vein arrays formed in competent layers in a stratabound environment and so were poorly interconnected to form fluid flow paths. In MacCormack area the absence of favourably oriented shear for reactivation may explain a higher fluid pressure allowing hydrofractures formation within the shear but also within the host rock. These hydrofractures are rarely connected and only form isolated arrays which unable large fluid flow.

Quartz veining in Archean shear zones illustrate therefore several modes of fluid circulation, time and space dependant: (1) transient, pulsative, fault valve – style circulation, that have been correlated with aftershocks development on seismic fault zones; such fluid could travel on long distance, allowing mineral concentrations; (2) limited fluid circulation in competent layers, with in-situ mobilization of element; (3) explosive hydrofracturing, in zone of low permeability, indicating exceptional pressure build-up. The two latter processes are not indicative of large fluid circulation. Hydraulic connectivity within these faults appears as a key dynamic factor.

Acknowledgements

This research was funded by the Natural Sciences and Engineering Research Council of Canada and Cartier Resources Inc. P. Berthelot and R. Deroff from Cartier Resources Inc. and A. Tremblay from UQAM are thanked for their contribution to field data collection and discussions. Stéphane Faure is thanked for helpful discussions.

References

Gillespie, P.A., Johnston, J.D., Loriga, M.A., McCaffrey, K.L.W., Walsh, L.L., Watterson, L., 1999, Influence of layering on vein systematics in line samples, In: McCaffrey, K.J.W., Lonergan, L., Wilkinson, J.J. (Eds.), Fractures, Fluid Flow and Mineralization: Geological Society, London, Special Publication 155, 35-56.

Robert, F., and Poulsen, K.H., 2001, Vein formation and deformation in greenstone gold deposits: Reviews in Economic Geology, 14, 111-155.

Sibson, R.H., Robert, F., Poulsen, K.H., 1988, High-angle reverse faults, fluid-pressure cycling and mesothermal gold quartz deposits: Geology, 16, 551-555.