Tectono-metamorphic framework of the Rosebel and Armina unit, French Guiana.

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SUMMARY

In Frecnh Guiana, gold mineralisations are well known. However, the geological history of the gold-bearing unit remains hill studied. We here present the first tectonometamorphic study including state of the art pressure temperature condition determination of the Armina and gold-bearing Rosebel unit of French Guiana. Our study point to two deformation phase at least that can be linked to the main (D2a) and late (D2b) Transamazonian events. Our petrological study point that the Rosebel unit suffered metamorphic condition at the greenschist to amphibolite facies transition favourable for gold deposit formation whereas the Armina unit clearly suffered regional amphibolite facies condition.

Key words: petrological study, Guiana shield, Greenstone belt, mineral exploration.

INTRODUCTION

Gold mineralisation is well known in French Guiana and occurs mostly in the two greenstone-belts that crop out in the northern and southern part of the French Guiana. Among these belts, the north one is mainly composed of meta-volcano-sedimentary rocks (Armina unit; metapelite and quartzite) and meta-detrital rocks (Rosebel-Bonidoro unit, metaconglomerate) (e.g. Kroonenberg et al., 2016; Naipal and Kroonenberg, 2016). Two main deformation events (D1 and D2) are usually described. The D1 is poorly documented and was not described in the Rosebel-Bonidoro unit (Egal et al., 1995, 1994, 1991), whereas in the Armina Formation, D1 was characterised by tiny oriented sericite mineralisation (Egal et al., 1995, 1994, 1991). The D2 event was described in both the Armina and Rosebel-Bonidoro units. Two main deformation stages are known. The first one (D2a-b) is a NE-SW sinistral transtension sliding followed by a sinistral stretching (Daoust et al., 2011; Delor et al., 2003; Egal et al., 1991, 1994, 1995). The second one (D2c?) was identified in the Rosebel gold deposit district (Surinam), where a NE-SW to N-S dextral transpression was described (Daoust et al., 2011). This later is characterised by tension and shear veins that are associated with gold mineralization which is assumed to be coeval to a late transamazonian event (2.023-1.955 Ga) and to the late calc-alkaline volcanism and plutonism of the south Guiana Schield (Daoust et al., 2011).

In French Guiana, gold mineralisation was also described in both the Rosebel-Bonidoro and Armina units (Nagel 1996 and references therein). Nevertheless, neither petrological nor metamorphic studies were conducted on these units since the work of Vanderhaeghe et al. (1998) and Delor et al. (2003). A complete study of the structure (Armina and Rosebel units) of the French Maroni bank was provided by Egal et al. (1991). Blast of biotite related to a static thermal metamorphism was described in the Armina unit, but garnet-amphibole-tourmaline-epidote assemblage is not well characterised in terms of pressure-temperature (PT) condition.

In a recent drilling water program, garnet-staurolite bearing micaschist was identified in the Armina formation by the French Guyana geological survey. Garnet and staurolite appear as porphyroclast and suggest an amphibolite facies metamorphism. Furthermore, Cassard et al. (2008) suggested that the Armina unit gold deposit has been under evaluated.

The drilling program conducted by the BRGM in the GU04K district (Rosebel unit; Espérance (drills ESP1-2-3)) of the French Guiana mining inventory has shown that gold-bearing quartz veins are parallel to the main foliation suggesting that these structures are syn-metamorphic structures. Nevertheless, related metamorphism and gold mineralisation are assumed to be coeval to intrusion of granitoïd (Egal et al., 1991; Plat and Lamouille, 1982). In the Cayenne area, the Rosebel-Bonidoro unit recorded an amphibolite facies metamorphism during the D2 event, estimated P-T provided by Vanderhaeghe et al. (1998) are around 4-7 kbar and 575-645°C. Important gold deposits were also described in this area (e.g. Kaw montain ; Nagel 1996 and references therein).

RESEARCH APPROACH

In this context, the objectives of the project are to provide new petrological and thermobarometric constrains on the PT condition path of both the Rosebel-Bonidoro unit and the Armina unit. It will contribute to provide a better geological understanding for gold mineralisation exploration and for gold unit mapping.

We studied a geological transect from Apatou to Grand Santi, along the Maroni riverbank as well as cores from the Sparouine an Esperance drills. We collected fifty samples in the field (Maroni transect and cores) amongst which we sent 20 for geochemical analysis (major and trace elements). We considered the tectonic setting diagram of Pearce et al. (1984) as a first order proxy to study the source of our samples. We conducted a detailed petrological study of 50 thin section under the microscope. Amongst these samples, we chose 13 for detailed petrological and analytical work, including Ti in biotite thermometry (Henry et al., 2005). We also selected a set of 4 samples for maximum temperature determination using the Raman spectroscopy on carbonaceous material (Beyssac et al., 2002) and 15 others for detailed microtectonics. Finally, we selected 4 sample to construct PT pseudosection using Perple_X and the relevant thermodynamic database (Connolly, 2009, 2005; Holland and Powell, 2011).

BUILDING UP THE TECTONOMETAMORPHIC FRAMEWORK ALONG THE MARONI TRANSECT

Thin section observation confirms the sedimentary nature of the Rosebel Bonidoro and Armina unit samples and allow to decipher their geological history:

- In the Rosebel Bonidoro unit, samples consist of detrital rocks in which we observe mainly a mild foliation that develops parallel to the bedding. In these, metamorphic minerals (e.g. biotite, garnet, epidote) are generally detrital. Some samples exhibit a more important development of the foliation and experienced grain size reduction. They were typical identified as possible shear zone in the field. Metamorphic minerals consist of biotite, both in the main fabric or postdating it, garnet detrital or metamorphic and epidote that is both detrital and metamorphic. One sample shows a chloritoid, chlorite quartz, muscovite, ilmenite assemblage were the rosette shaped chloritoid show a statice growth.

  Our microtectonic study on the most deformed samples give both sisnitral and dextral sense of shear. The deformation fabrics consist of quartz recrystallization by sub grain rotation, undulose extinction of quartz, sigma clast of quartz, mica fish structures and shear band cleavage fabrics. The majority of samples show sinistral sense of shear. Only a few ones yielded dextral sense of shear that were not documented yet in this region but known in the Rosebel unit (e.g. Daoust et al., 2011). In a sample, the dextral sense of shear postdate the sinistral movements.

  All petrological method we applied (RSCM, Ti in biotite thermometry and pseudosection modelling) point to temperature of metamorphism for the Rosebel unit sample of 550±50°C. The pressure is constrained on two samples between 0.3 to 0.5 GPa using pseudosection modelling.

  Major elements show that our rocks are peraluminous, intermediate to acidic, with a chemistry of a diorite to granite. Using the Nb/Y and the Ta/Yb diagram of Pearce et al. (1984) our samples plot in the volcanic arc orogeny field.

- In the Armina unit, the garnet staurolite micaschist of the Sparouine drill shows a well-developed lepiboblastic fabric. The assemblage is made of garnet, staurolite, biotite, muscovite, quartz, feldspar, tourmaline and ilmenite. Both the staurolite and garnet appear at equilibrium. We could not study the deformation in this series of samples as they were taken in non-oriented cores. Altogether, the Ti in biotite thermometry, Raman thermometry and pseudosection modelling point to a temperature of climax metamorphic condition at 600 ± 50°C and a pressure of 0.48 ± 0.1 GPa. The geochemical affinity is similar to that of the Rosebel samples (volcanic arc orogeny, granitic chemistry and peraluminous).

IMPLICATIONS FOR MINERAL EXPLORATION

Our study shows clear differences in PT conditions between selected samples and studied area. Specifically, there is a great difference between garnet-staurolite bearing miscaschists of Sparouine (Armina formation) and quartzites of Esperance, which is well known as gold-rich part of the Rosebel-Bonidoro formation. In Armina formation, Cassard et al. (2006), based on a gold predictivity mapping, suggest that the Armina Formation was underestimated in terms of gold potential. Our preliminary PT data does not support such a conclusion. Indeed, orogenic gold mineralisation are commonly found in greenschist to amphibolite facies units (Phillips and Powell, 2010). Thus, gold investigation in this unit must be taken with caution in the Armina formation and staurolite-garnet micaschist does not seems to be a good target. However, the Rosebel formation stands at this metamorphic transition. Furthermore, ductile deformation in Esperance sample (i.e., protomylonitic to mylonitic related to regional shearzone) was not identified in the other place of the Rosebel-Bonidoro unit meaning probably that gold deposit need both greenschist PT condition and regional ductile deformation. Shear zone are not well identified in French Guiana or Surinam. It could be interesting to focus exploration on identifying those shear zones.

CONCLUSIONS

We provide the first quantitative PT condition for both the Rosebel and the Armina unit. In the Armina unit, the staurolite-garnet bearing micaschist recorded peak PT condition of 0.48 ±0.1 GPa and 600 ± 50°C. This combined with the occurrences of other staurolite-bearing micaschist in French Guiana and in Suriname point towards a metamorphism a regional origin for this unit. In the Rosebel unit, the calculated PT condition show climax condition on 0.4 ± 0.1 GPa and 500 ± 50°C. We point that all independent petrological methods are in very good agreement for both the Rosebel and Armina unit. Further investigation could strengthen this point, for example with the comparison of the “upper sedimentary units” in Mt Tortue area of Western French Guaina where petrological studies point to similar but not yet quantitative PT conditions (Vanderaeghe et al., 1998). In a similar way, this points the need to better constrain the staurolite bearing Armina unit that extend farther west to Surinam (e.g. Kroonenberg et al., 2016).

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