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PROGRAMME AND EXTENDED ABSTRACTS

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Shear zones and structural analysis of the Loimaa area, SW Finland

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Shear zones of various ages and orientations are common in Southern Finland. In the study area, E-W and N-S trending shear zones are the dominant structural feature. Mylonitic foliations were identified from the most intensely sheared rocks. Ductile shearing has mainly been of dip-slip type. Structural mapping revealed several larger map-scale folds, which appear to be relatively continuous across the study area from SE to NW. In the central area, folding interfered with the shear zones causing a complex crustal structure such as associated with the Uunimäki mineralization. Aeromagnetic and lithological maps, field observations, stereographic projections and oriented thin sections were used to determine the structural features of the study area.

Keywords: Shear zone, structural geology, fold, deformation, mylonite, aeromagnetic map

1. Introduction

The two-year project “Spatial distribution of gold mineralizations in SW Finland with respect to the crustal structure and hosting lithologies of the Häme and Pirkanmaa Belts” between the University of Turku and Geological Survey of Finland (GTK) was started in 2017. The aim is to provide information about the possible new and existing exploration targets with the structural, geochemical, geochronological and lithological data (see also Kara et al., 2018; Leskelä et al., 2018; this issue). The main objective of this study is to form a model of the structural features in the Loimaa area in SW Finland, which might have linkages with gold and other mineralisations (Fig 1).

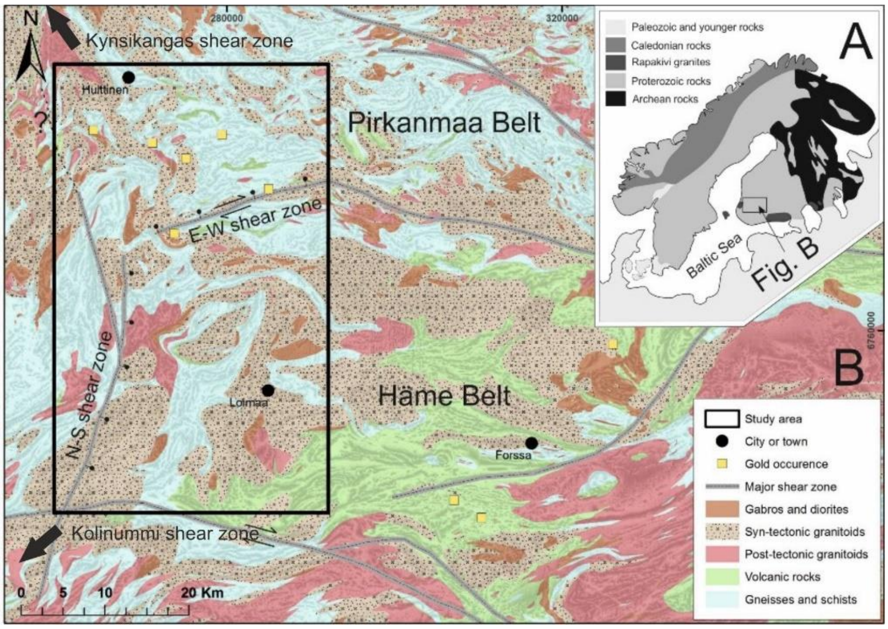

Fig. 1. A) Geological overview of the Fennoscandian shield (Koistinen et al. 2001), B) Geological map of the Häme belt presenting the study area, major shear zones and gold prospects (Bedrock of Finland – DigiKP).

2. Regional geology

The study area is located in the western end of the E-W trending Häme belt, which is part of the Svecofennian domain in the Central Fennoscandian shield (Fig. 1). The Häme Belt consist of 1.89-1.87 Ga plutonic-volcanic rocks with volcanic arc affinities (Hakkarainen, 1994; Kähkönen, 2005; Mäkitie et al., 2016), which have undergone metamorphism mainly in the amphibolite facies conditions (e.g. Nironen, 1999; Hölttä and Heilimo, 2017). The area hosts several known gold occurrences (Kärkkäinen et al., 2012).

3. Study material

The data consist of 484 bedrock observations. Tectonic features measured were the foliations, lineations, fold axes, axial surfaces, faults and, in some outcrops, fractures and veins. The main emphasis in selecting the observation targets was put in the areas of the two major shear zones. However, observations from the surrounding areas were also collected, including the major fold systems. For the kinematic renditions, oriented samples for thin sections were collected from the most promising outcrops. One sample was taken for zircon U-Pb geochronology from a granite intruding the N-S shear zone.

4. Delineation of the structural domains based on the structural data

The study area was divided into subareas based on the dominant structural signatures. The subarea division utilized both the aeromagnetic signatures of the crust, as well as field mapping data. The subareas are the ***N-S shear zone***, ***E-W shear zone***, ***North fold***, ***Alastaro fold***, ***Oripää fold*** and ***Uunimäki gold prospect*** (Fig. 2). Both shear zones are ductile, which involve strain releasing along the forming shear bands and mylonites with kinematic features. Location of the North fold between the N-S shear zone and the Kynsikangas shear zone (Fig. 1) have a potential to enlighten their correlation. The Oripää fold in the SE is the least affected by the two shear zones. The Alastaro fold is located south of Uunimäki and between the other two major fold systems, and it is more incoherent than the North fold or the Oripää fold.

4.1 Shear zone domains

The ***E-W shear zone*** (C in Fig. 2) is characterised by penetrative foliation and gneissic banding. Mylonitic foliation was observed only on a few outcrops, which characterise zones of most intense deformation. Planar and linear fabrics are mainly moderately or steeply inclined. Dextral shear sense was observed from these outcrops and thin sections. Since the collected structural data from the ***N-S shear zone*** (D1-D4 in Fig. 2) is not as homogeneous as the E-W shear zone, the area was subdivided into four subareas. Similar to the E-W shear zone, most planar and linear structures are the steeply to moderately inclined. Foliations of the southernmost subarea (D1) are NE-SW striking and the structures are most likely related to other shear zone in SW known as the Kolinummi shear zone (Fig. 1)(Väisänen and Skyttä, 2007). L-tectonites were locally observed from this subarea, while the other three subareas mainly contain S-tectonites and some S-L-tectonites. The NNE-SSW striking negative magnetic anomaly is visible on the map, possibly representing the continuation of the N-S shear zone towards SSW. Mylonitic textures and strong recrystallization of quartz characterise the structures in the next subarea towards north (D2). Mainly steeply-dipping foliations were observed, including mylonitic foliations on the best outcrops. Gently to sub-vertically plunging lineations are mainly weak to strong mineral or stretching lineations. Shear deformation-related major folding with axes plunging gently or moderately towards N-NNE was observed from subarea D3. Within the D4 sub-area the dominant structural trends are NNW-SSE.

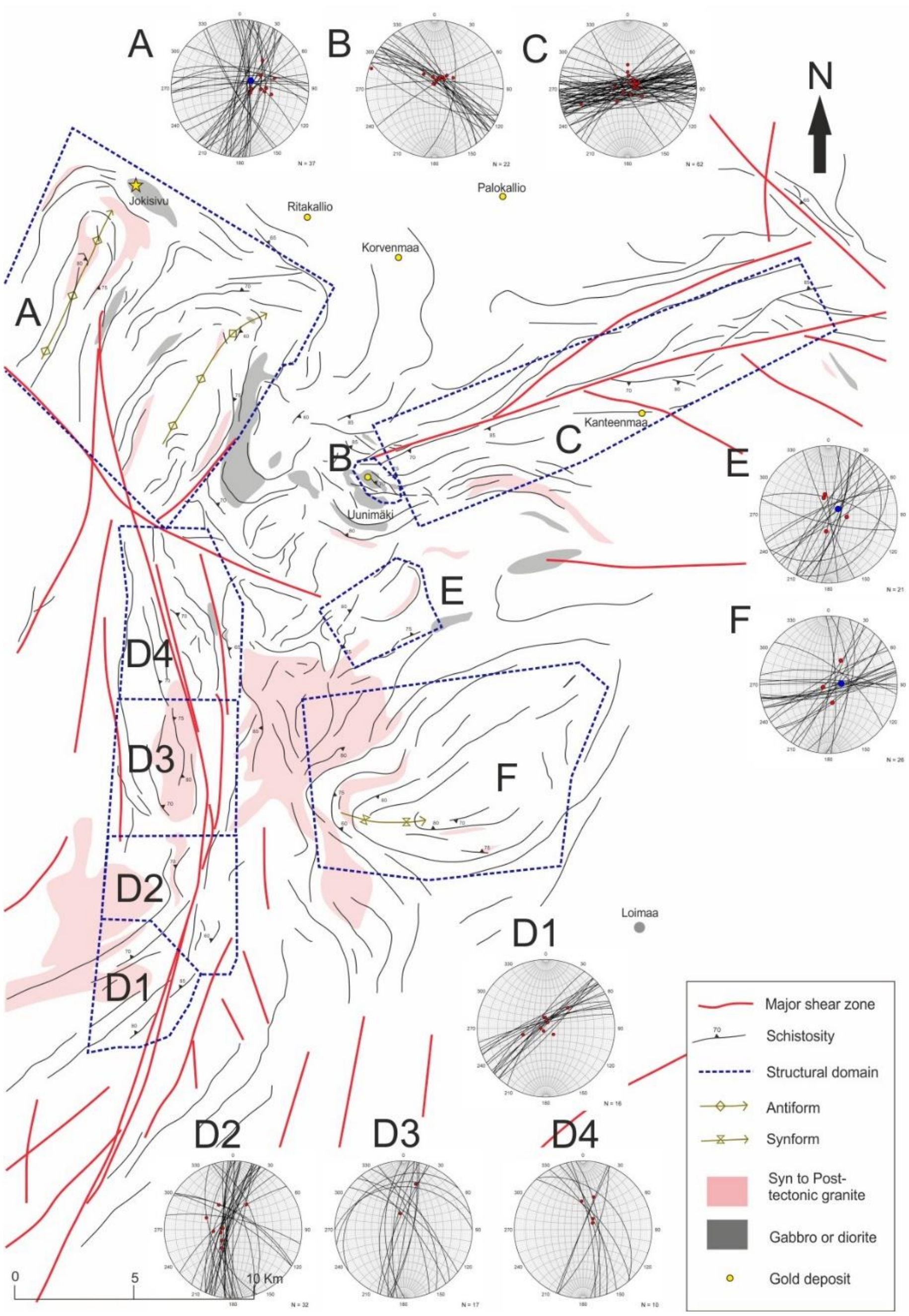

Fig. 2. Structural map of the study area, structural domains (A-F) and stereographic projections of the dominant planar (great circles) and linear (lineation; dots) features.

4.2 Folded domains

Major fold areas include the ***North fold***, ***the Alastaro fold*** and the ***Oripää fold*** (A, E and F in Fig. 2). The data collected from the Oripää fold area indicate a major synformal structure. The calculated major fold axis plunges steeply towards east (086/69). Plunges of the mineral lineations range at 47°-80°. From the North fold area, the data suggests two antiforms with steeply NE plunging fold axes (055/68). Penetrative foliation and schistosity were the most common type of planar features of the area, and some mylonitic and pseudotachylitic textures were observed from narrow zones. The more incoherent Alastaro fold south of Uunimäki contain Z and S type of folds on outcrops and the NE-plunging steep fold axis (060/72) was calculated from foliations.

5. U-Pb zircon dating

In order to estimate an age of the shear activity, a granite intruding the N-S shear zone was sampled for zircon dating. The dating was performed in the Finnish Geosciences Research Laboratory at GTK. The data revealed several age populations ranging from Archean to Paleoproterozoic. The youngest population yield an upper intercept age of ~1.87 Ga.

6. Conclusions

A continuous chain of major folds (A to F in Fig. 2) has evolved in collision prior to the generation of the major shear zones. As a result of the folding and shearing, a very complex crustal structure was generated, e.g. in mineralized Uunimäki area (B in Fig. 2). Different shear sense between the N-S and Kynsikangas shear zones indicates separate deformation events. Structures in the subarea D1 are probably related to the nearby Kolinummi shear zone in the SW (Väisänen and Skyttä 2007). The kinematic indicators within the N-S shear zone are supporting west side-up movement. The E-W shear zone shows south-side-up movement. Dextral strike-slip component has also been significant in some parts of the E-W shear zone.

The zircons from the granite within the shear zone contain several inherited populations. The youngest ~1.87 Ga population is, within errors, similar to that obtained from the nearby Oripää granite (Kurhila et al. 2005). That age was interpreted to be inherited from the source. That is also probably the case in this study.

7. Acknowledgements

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References

Bedrock of Finland - DigiKP. Digital Map Database [Electronic Resource]. Espoo: Geological Survey of Finland [referred 17.10.2018]. Version 2.0.

Hakkarainen, G., 1994. Geology and geochemistry of the Hämeenlinna-Somero volcanic belt, southwestern Finland: a Paleoproterozoic island arc. Geochemistry of Proterozoic Supracrustal rocks in Finland, 19, 85-100.

Hölttä, P., Heilimo, E. 2017. Metamorphic Map of Finland. Bedrock of Finland at the scale 1:1000 000 – Major stratigraphic units, metamorphism and tectonic evolution. Geological Survey of Finland, Special Paper, 60, 77-128.

Kara, J., Manninen, J., Leskelä, T., Skyttä, P., Väisänen, M., Tiainen, M., Leväniemi, H., 2018. Characterization of the structural evolution and structural control of the gold mineralizations in the Kullaa Area, SW Finland. Institute of Seismology, University of Helsinki, Report S-6X, xx-yy.

Koistinen, T., Stephens, M.B., Bogatchev, V., Nordgulen, Ø., Wennerström, M. Korhonen, J., 2001. Geological map of the Fennoscandian Shield, scale 1:2 000 000. Geological Surveys of Finland, Norway and Sweden and the North-West Department of Natural Resources of Russia.

Kurhila, M., Vaasjoki, M., Manttari, I., Ramo, T., Nironen, M. 2005. U-Pb ages and Nd isotope characteristics of the lateorogenic, migmatizing microcline granites in southwestern Finland. Bulletin-Geological Society of Finland, 77, 105-128.

Kähkönen, Y., 2005. Svecofennian supracrustal rocks. Developments in Precambrian Geology, 14, 343-405.

Kärkkäinen, N., Huhta, P., Lehto, T., Tiainen, M., Vuori, S. Pelkkala, M. 2012. New geochemical data for gold exploration in southern Finland. Geological Survey of Finland, Special Paper, 52, 23–46,

Leskelä, T., Kara, J., Pitkälä I., Skyttä, P., Väisänen, M Tiainen, M., Leväniemi, H., Hokka, J. Lahaye Y. Geochronology, geochemistry and structural setting of the Uunimäki gold mineralisation, SW Finland. Institute of Seismology, University of Helsinki, Report S-6X, xx-yy.

Mäkitie, H., Kärkkäinen, N., Sipilä, P., Tiainen, M., Kujala, H., Klami, J., 2016. Hämeen vyöhykkeen granitoidien luokittelua. Geological Survey of Finland archive report 33, 146p.

Nironen, M. 1999. Structural and magmatic evolution in the Loimaa area, southwestern Finland. Bulletin of the Geological Sociecity of Finland, 71, 57-71.

Väisänen, M., Skyttä, P., 2007. Late Svecofennian shear zones in southwestern Finland. GFF, 1