

BARENTS PROJECT 2013

Geological and geophysical studies in the Harrijärvet, Vittangivaara and Akkiskera-Kuormakka key areas

Stefan Luth, Edward P. Lynch, Susanne Grigull, Mats Thörnelöf,
Robert Berggren & Johan Jönberger

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Cover: View from the west towards Mount Kuormakka.

Sveriges geologiska undersökning
Box 670, 751 28 Uppsala
tel: 018-17 9000
fax: 018-17 92 10
e-post: sgu@sgu.se
www.sgu.se

CONTENTS

Sammanfattning	4
Summary	4
Introduction	5
Harrijärvet and Vittangivaara	5
Harrijärvet	6
Stratigraphy	6
Structural observations	7
Revised structural interpretation	8
Western Vittangivaara	9
Revised structural interpretation	12
Eastern Vittangivaara	13
Stratigraphy	13
Structural observations and interpretations	14
Regional interpretation	15
Akkiskera-Kuormakka	17
Stratigraphy	18
Structural observations	20
Interpretation of the alteration pattern	22
References	24

SAMMANFATTNING

Denna rapport beskriver de geologiska observationerna från fältsäsongen 2013 i tre nyckelområden: Harrijärvet, Vittangivaara, och Akkiskera-Kuormakka. Samtliga ligger i norra Norrbotten. Områdena är tre av de 15 nyckelområden som valts ut inom Barentsprojektet. Observationerna bidrar till en bättre förståelse av regionens geologiska historia, stratigrafiska uppbyggnad, tektoniska rörelser samt utvecklingen av mineraliseringar och malmkroppar.

SUMMARY

This report summarizes geological observations from the 2013 field period carried out in the Harrijärvet, Vittangivaara and Akkiskera-Kuormakka areas in northern Norrbotten. These areas represent three of 15 key areas that are being investigated within the context of SGU's Barents project. The field observations contribute to a better understanding of the region's geological history in terms of stratigraphy, tectonics and mineralisation.

INTRODUCTION

During the summer of 2013, field work was carried out by SGU's geologists and geophysicists within eight key areas in the Kiruna region of northern Sweden. The field work forms part of SGU's Barents project, which covers a total of 15 key areas throughout the Norrbotten county. The project aims to better constrain the region's stratigraphic and tectonic evolution and related metallogenic processes.

This report briefly summarises field activities performed within three key areas located north of Kiruna: Harrijärvet, Vittangivaara and Akkiskera-Kuormakka (Fig. 1). The type of data collected in these areas can be categorized as follows:

- 1) detailed lithological descriptions, (e.g. outcrop location and rock types),
- 2) bedrock samples (for thin sections, geochemistry, geochronology and petrophysics),
- 3) structural measurements (bedding, foliations, faults, lineations, kinematic indicators etc.), and
- 4) geophysical measurements (magnetic susceptibility and ground magnetometre profiling etc.).

In this report, an overview of the different data is presented for each key area using maps, stereographic plots and field photographs. The tectonic interpretations that follow the field observations are preliminary and validation based on upcoming field, laboratory and desk studies is ongoing.

HARRIJÄRVET AND VITTANGIVAARA

Field work within the Harrijärvet and Vittangivaara key areas was concentrated to five observation clusters (Fig. 2). The southernmost observations, in the Kovo Zone, were made on outcrops along a forest road, whereas the other four observation clusters were accessed by helicopter. Dur-

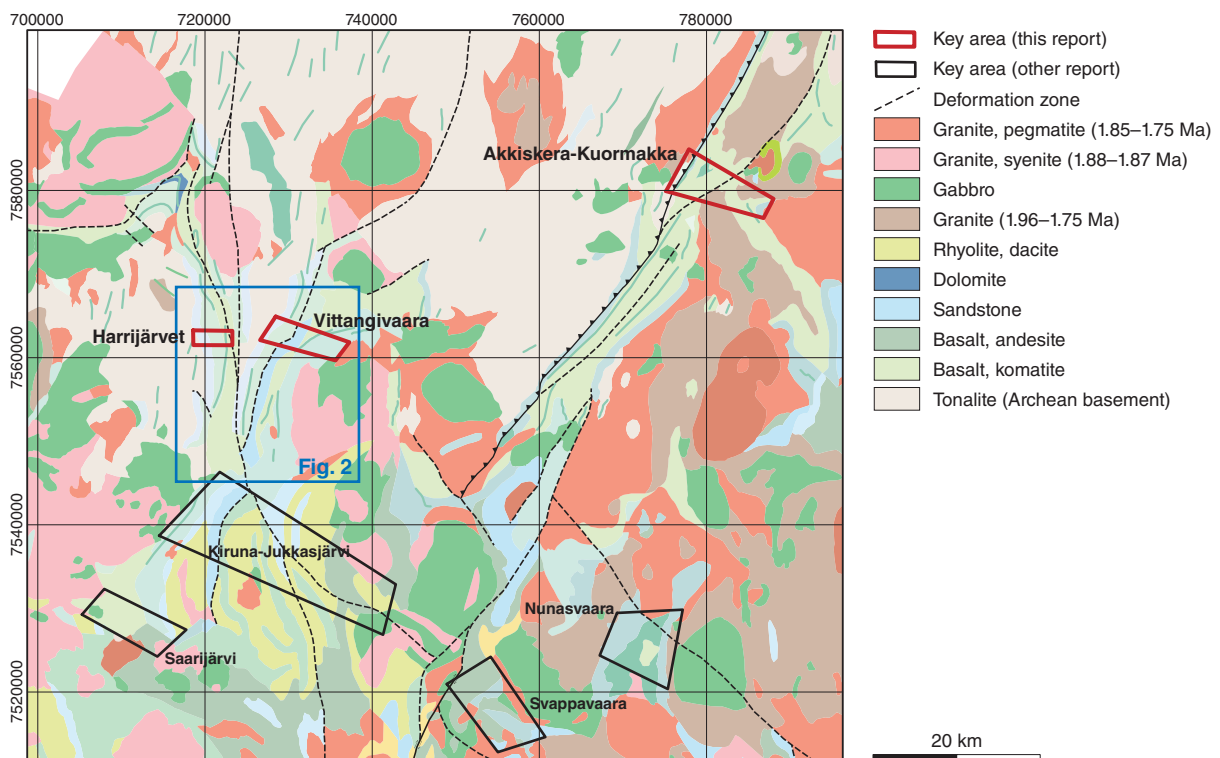


Figure 1. Locations of the three key areas presented in this report: Harrijärvet, Vittangivaara and Akkiskera-Kuormakka.

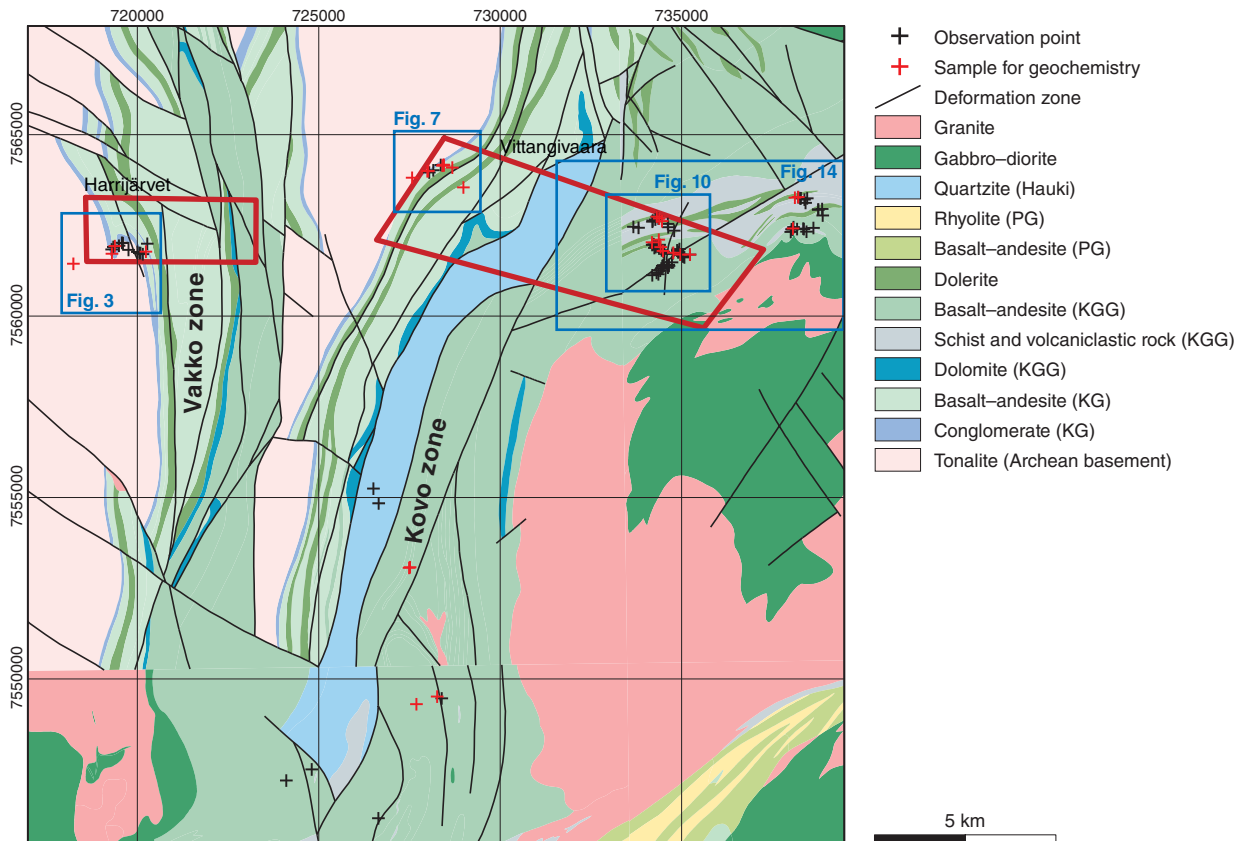


Figure 2. Observations and sample locations in the Harrijärvet and Vittangivaara areas. PG: Porphyry group, KGG: Kiruna greenstone group, KG: Kovo group.

ing the field work, the two major stratigraphic units within the Kovo Zone, namely the Kovo group and the Kiruna greenstone group, were successfully accessed and sampled. Further to the west, mapping in the Harrijärvet area (or Vakko Zone) mainly focused on the folded contact between the Archean basement in the west and overlying conglomerates and volcanic rocks assigned to the Kovo group in the east. In the following section some key observations from the Harrijärvet and Vittangivaara areas are described. The observations from the southern Kovo Zone as well as from the mountain Vittangivaara (northeastern corner) are discussed as part of the Vittangivaara key area.

Harrijärvet

The aim of the field work conducted in the Harrijärvet area was to study the contact between the Archean basement to the west and the overlying Kovo group to the east (Fig. 3). An earlier published map (Martinsson 1999) shows that the contact between these units is folded. This interpretation is mainly based on geophysical data (Luth & Antal Lundin 2013). In order to investigate whether this fold geometry represents a tectonic feature re-mapping and sampling along an east–west profile perpendicular to the fold structure was conducted (Fig. 3).

Stratigraphy

From the mapping we confirmed the presence of the main rock types as shown on the Ren-sjön map (Martinsson 1999), namely granodiorites, conglomerates and basalts. In addition, we observed that the granodiorite of the Archean basement is intruded by metre-thick mafic sills.

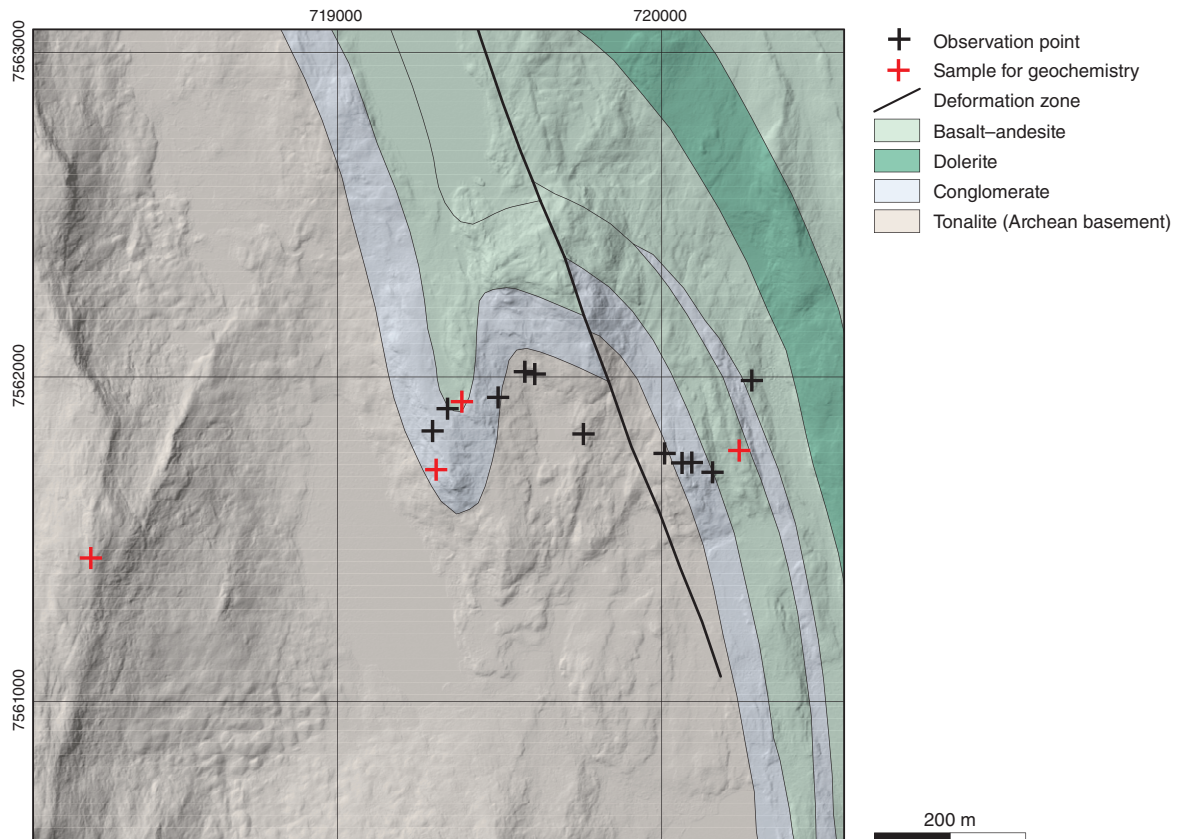


Figure 3. Observations and sampling locations in the Harrijärvet key area.

Furthermore, dolomite layers hosting sulphides are also present. The contact with the overlying conglomerate was not observed, but it was constrained to within several metres. This sedimentary unit has an estimated thickness of 200–300 m. The conglomerate contains well rounded and somewhat elongated granite and quartzite pebbles varying in size between a few centimetres and 80 cm within a poorly-sorted, sand-rich matrix (<5%, Fig. 4c). Higher up in the stratigraphy, the conglomerate alternates with sandstone layers which have been sampled for a zircon provenance study (Fig. 4d). The upper contact with the overlying basalts was not exposed. The basalt is very fine-grained and does not appear to be altered. Upcoming studies on thin-sections and geochemistry, however, will be used to further address the unit’s mineralogy.

Structural observations

Most of the structural measurements were made on foliation planes, which are best developed within the Archean basement unit, in addition to the overlying basalt and conglomerate (Fig. 5). Although the Archean unit probably underwent multiple phases of deformation, based on the presence of small-scale re-folded folds, the measured foliations represent the most dominant and traceable fabric in this unit. It appears both as a penetrative foliation on a millimetre-scale as well as a spaced cleavage on a centimetre-scale. Foliation and cleavage orientations vary from north-east to north-west, and reveal a fanning geometry on a regional scale. This is consistent with an expected axial planar cleavage related to the mapped fold geometry (Fig. 5). Lineations on the foliation planes were only rarely observed and do not show a constant direction. In addition, some localized north- to north-north-west-trending shear zones were observed within,

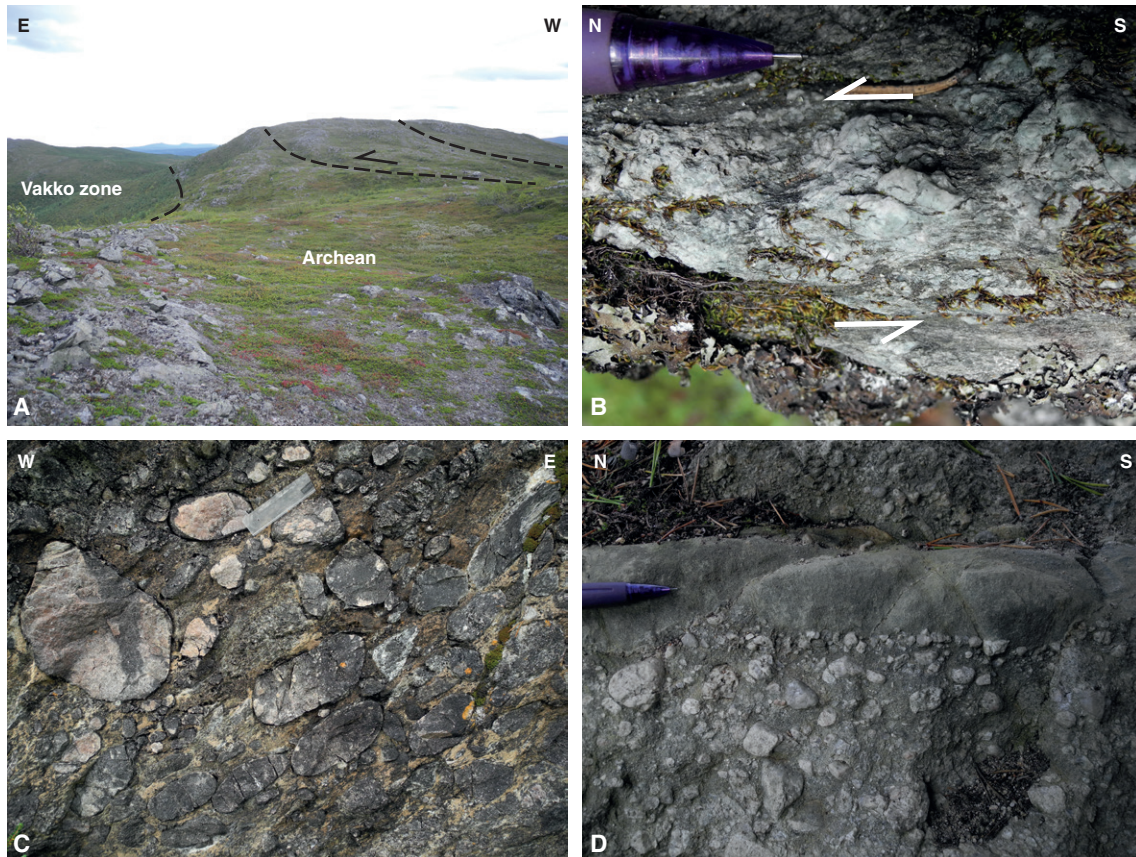


Figure 4. A. Archean basement west of the Vakko zone may have been internally thrust towards the east (7561442/718240, slh131081). B. Sinistral shear in mylonitic rock inferred from imbricated feldspar clasts (7561824/719759, slh131072). C. Strained pebbles of granite in the lower Kovogroup (7561706/720157, slh131076). D. Sandy layer or mafic sill in conglomerates of the lower Kovogroup (7561924/719384, slh131079).

but probably not restricted to, the Archean basement. Within these shear zones, mylonite and chlorite-rich fault gouge occurs (Fig. 4b and 5).

Revised structural interpretation

Based on the new observations in combination with LiDAR data and magnetic anomaly maps, the lithological contacts and shear zones have been reinterpreted (Fig. 6). North-north-east trending shear zones cross-cut and left-laterally offset several major fold hinges. Sinistral displacements are supported by kinematic indicators, such as imbricated “fish-type” clasts observed in mylonites (Fig. 4b). These mylonite zones correlate well with some of the major escarpments seen on LiDAR elevation maps which can be traced for several kilometres towards the north. In addition, a sinistral displacement derived from kinematic indicators is consistent with the offset seen between high magnetic anomaly zones (Fig. 6). The timing of this shearing can be constrained only relatively to a post-folding phase. However, it may also be considered to represent an expression of progressive deformation where faulting directly followed folding.

The observed structures can be explained by two scenarios within the tectonic setting. In the first scenario, folding occurred as a result of east–west compression and was followed by a phase of north–south compression, which produced the faults. In a second scenario, both folds and shear zones were formed as a result of sinistral wrenching. In this case, the sediments of the

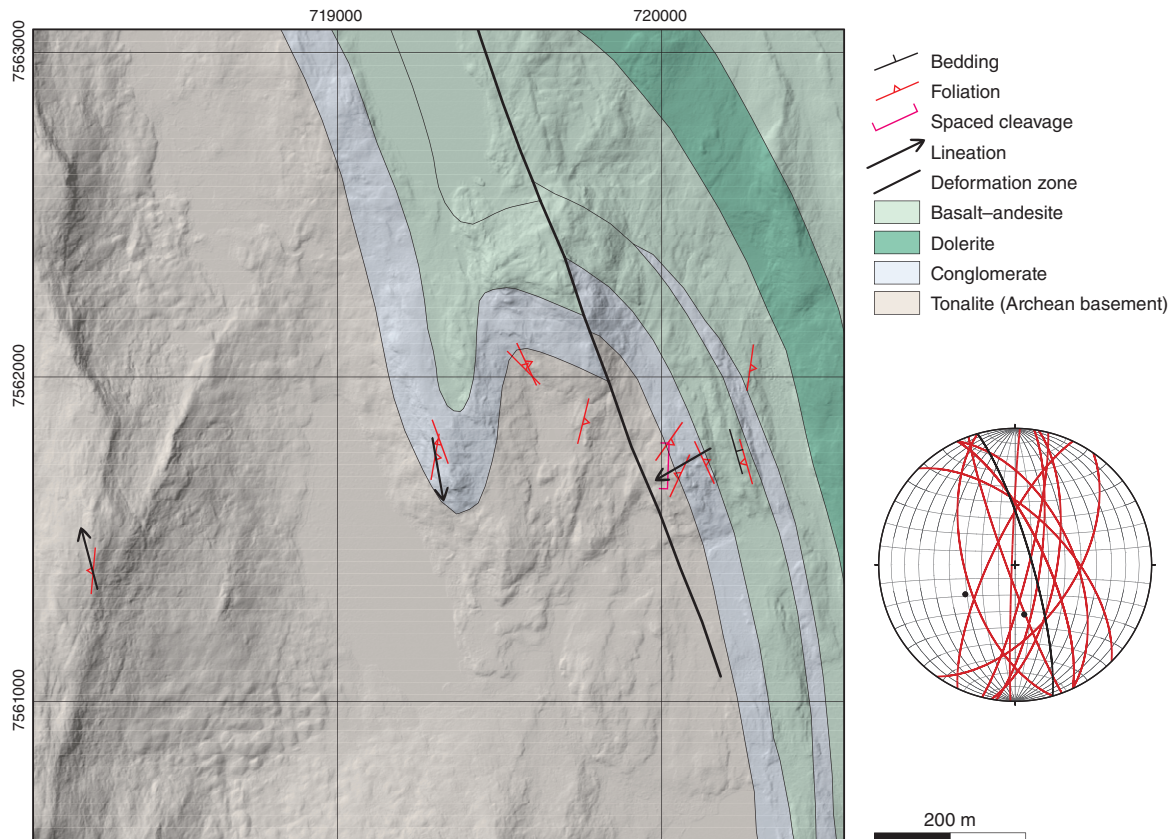


Figure 5. Structural measurements within the Harrijärvet area plotted on the geological map and as great circles in a lower hemisphere projection stereogram (upper right).

Vakko Zone moved northward with respect to the Archean basement leading to the formation of drag folds along the contact zones. Steeply dipping fold hinges support the second scenario, which is based on the mapped folding pattern as well the few measured lineations (Fig. 5). Note that this scenario, however, does not exclude the possibility of a folding phase predating a wrenching phase. In fact, the Vakko Zone probably underwent several phases of folding and the results of the final wrenching are the dominant structures seen today.

Based on a single observation an additional tectonic event may have postdated sinistral-wrenching in the western margin of the Harrijärvet area (Fig. 4a and 6). Here, the Archean basement seems internally thrust towards the east along a series of shallow-dipping thrust planes (Fig. 4a). At present, field evidence for a tectonic contact is lacking and thrusting is primarily based on topographic morphology and an observed shallow, westward-dipping, centimetre-spaced foliation. In addition, it appears from both LiDAR and geomagnetic anomaly maps that the thrust sheet overlays the westernmost strike-slip fault indicating that thrusting must have postdated sinistral wrenching. Hypothetically, this thrusting may have occurred during the Caledonian orogeny, of which the eastern thrust front is located only 30 km further to the west.

Western Vittangivaara

In the western part of the Vittangivaara key area, one day of mapping and geophysical profiling has been carried out focusing on the contact between the Archean basement in the west and the Kovo group, forming part of the Kovo Zone, to the east. The main issue was to better understand the nature of this contact and if it accommodated deformation.

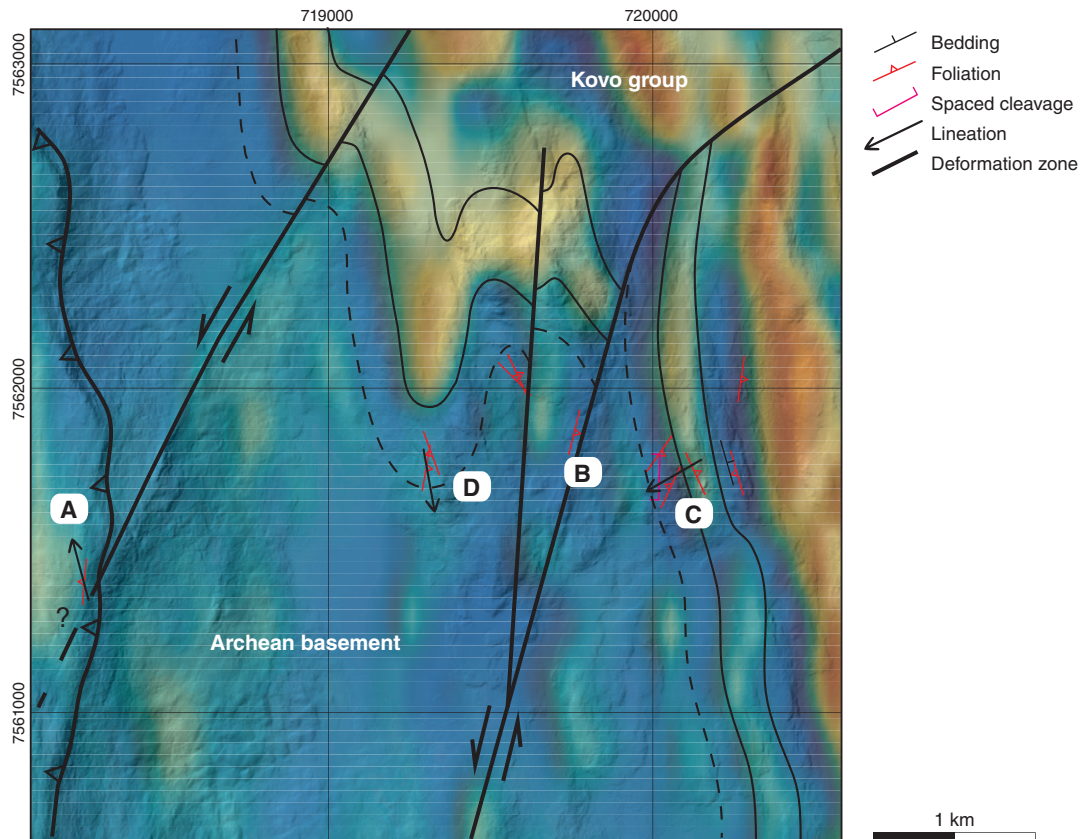


Figure 6. Revised interpretation of lithological contacts and structural lineaments based on an integration between geological key observations and the magnetic anomaly map (background, red color represents highly magnetic areas). Letters refer to the locations of the photographs shown in Fig. 4. Dashed line is the reinterpreted contact between the Archean basement and the overlying conglomerates of the Kovo group (compare with Fig. 5).

The Archean basement in the west consists mainly of (meta)granitic rocks and interlayers of amphibolites and gneisses. The degree of deformation locally varies from weak to very strong shearing within narrow zones. According to the existing 1:50 000 scale bedrock map (Fig. 7, Martinsson 1999) the basement is overlain by conglomerates that are similar to those observed in the Harrijärvet area. The observations on the south-western slope of Kruuvivaara (582 m), however, reveal that the bedrock is still composed of felsic crystalline, probably Archean rocks containing two sets of well developed spaced cleavages. These cleavages are most likely the result of low-temperature deformation, which is also supported by the high amount of broken feldspar clasts. Parallel to the predominant north–south cleavage trend, 20 m wide fault zones occur which can also be recognized as escarpments on the LIDAR elevation map. The fault-related rocks are very fine-grained, biotite-rich, intensely foliated and lineated, and host clast fragments that are up to 0.5 m large. No kinematic indicators were found.

Further to the north-east, a few metres east of the summit, a small outcrop reveals a mylonitic fabric (Fig. 8a). Asymmetrically sheared feldspar clasts in a mica-rich matrix forms a C-S fabric indicating western-side-up kinematics. No detailed observations of the microstructures have been made, but the rock's bulk composition appears granitic, which suggests that the rocks located directly west of this deformation zone are likely to be the less deformed equivalent. On the contrary, just a few tens of metres eastwards, a pervasive K-feldspar alteration has strongly

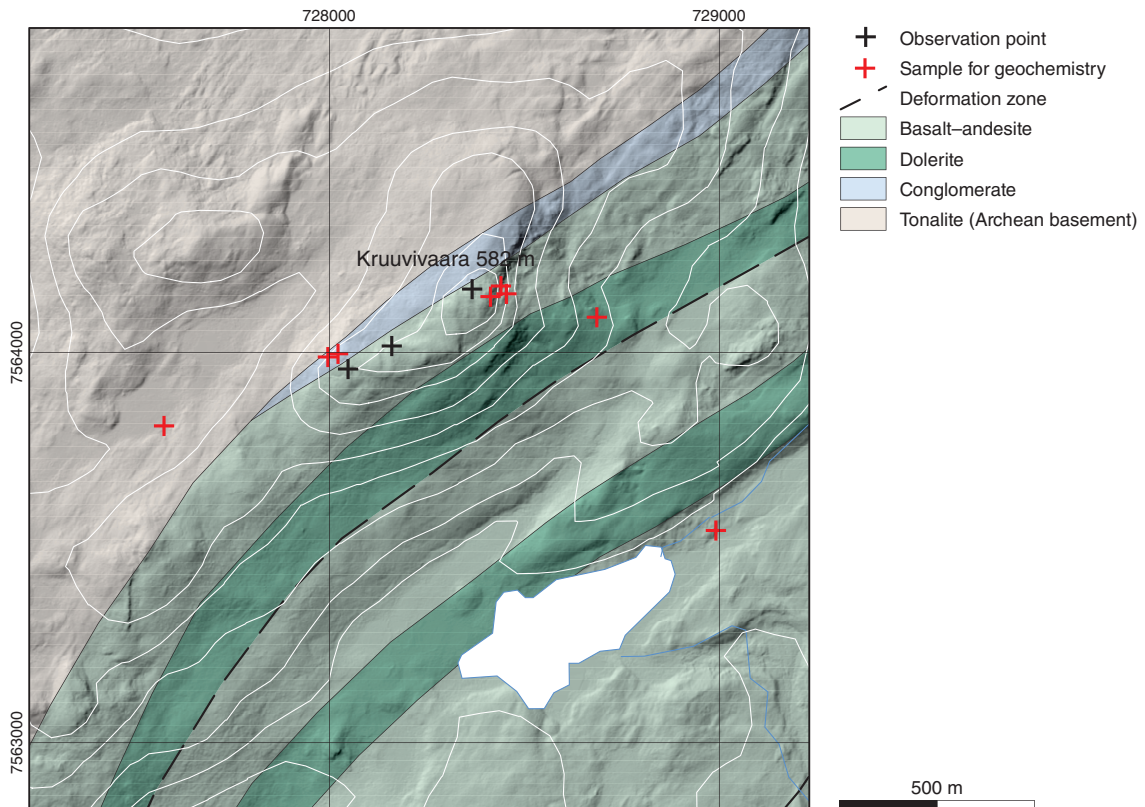


Figure 7. Observations and sampling locations in the western part of the Vittangivaara key area. “A” refers to location of the photos from Fig. 8.

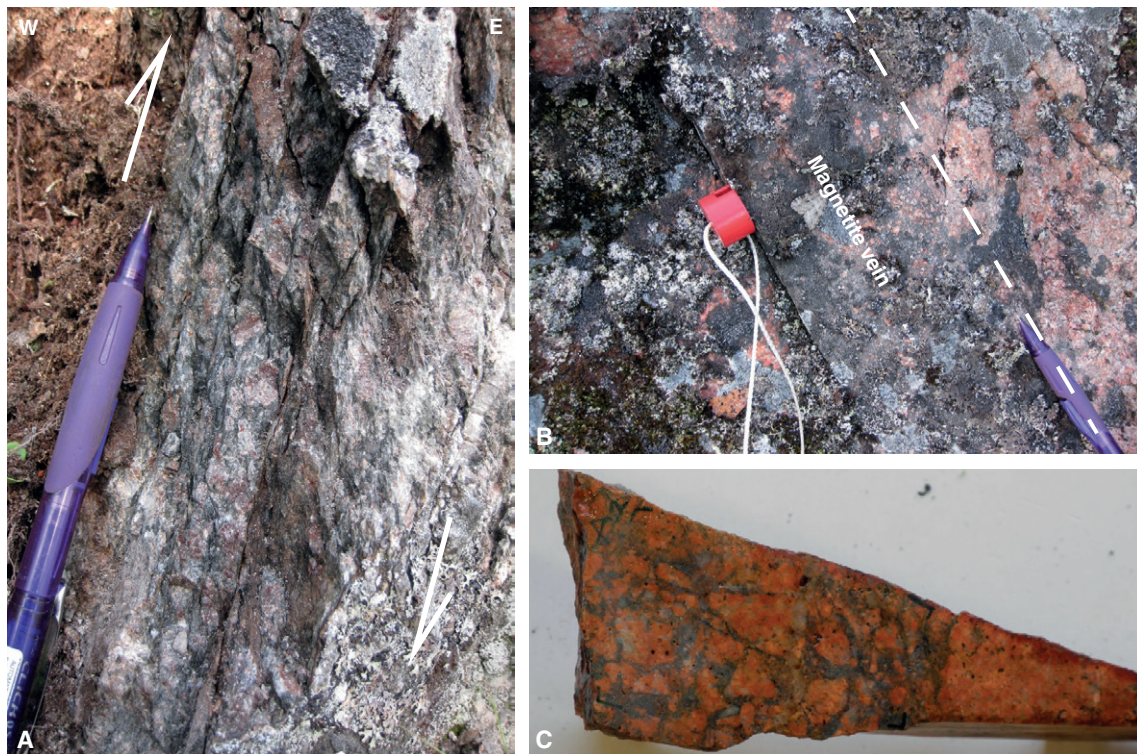


Figure 8. A. Mylonites with a C-S fabric revealing top-to-the-east sense of shear (7564155/728413, slh131062). B. Vein containing potassium-altered, angular clasts and a fine-grained matrix bearing magnetite and gold (2,8 ppm, 7564171/728440, slh131063). C. Sample from the magnetite-gold vein shown in b.

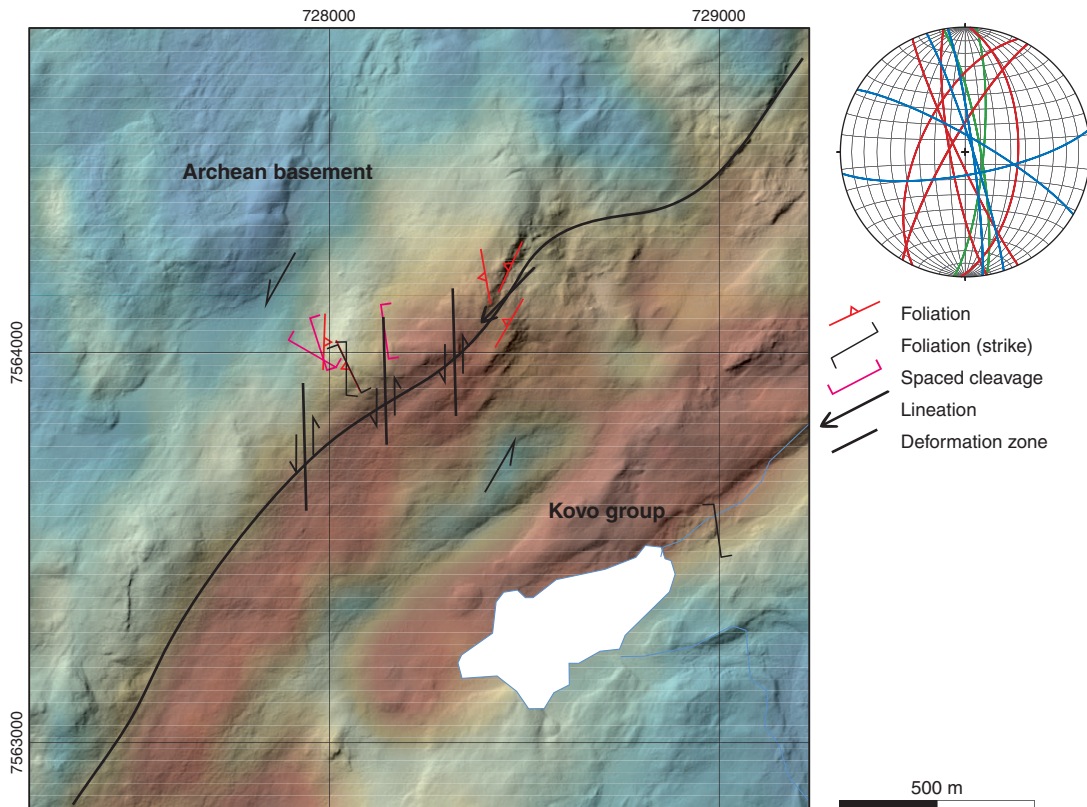


Figure 9. Structural measurements plotted as map symbols and as great circles in a lower hemisphere projection stereogram. Structural interpretation on the boundary between the Archean basement in the west and the Kovo group in the east (dashed line), drawn on the magnetic anomaly map (red color represents highly magnetic). The sinistral faults are interpreted from geological observations, elevation data and the magnetic anomaly map. These faults may represent Riedel-shears in an overall sinistral shear regime.

modified the rock's bulk composition. The pinkish rock consists of more than 80% K-feldspar and has been intruded and locally brecciated by veins rich in magnetite and gold (c. 2.8 ppm) (Fig. 8b, c). These veins are straight and continuous within the host rock, and therefore most likely relate to a relatively late hydrothermal event. Adjacent to this altered unit, strongly foliated, fine-grained phyllitic rocks appear. They may be interpreted as mylonitised meta-siltstones. Studies on thin sections may reveal the direction of shearing within these rocks. A reworked basaltic tuff within the Kovo Zone was also sampled.

Revised structural interpretation

The contact between the Archean basement and the Kovo group has been reinterpreted and moved towards the east (Fig. 9). The contact between both units is tectonic and characterised by a mylonite zone which is at least 50 m thick. The discrete, north–south trending shear zones (Fig. 9) observed around Kruuvivaara are interpreted as zones with sinistral displacement using the magnetic anomaly map. These fault may represent Riedel shears and are hence part of a larger sinistral displacement zone, which was localised along the Archean block. Ongoing thin section observations may confirm if the kinematics of the mylonite zone fit with such a fault system. Another challenging question is to what extent the rocks east of the mylonite zone, which are strongly affected by a pervasive K-feldspar alteration, brecciation and veining, relate to the

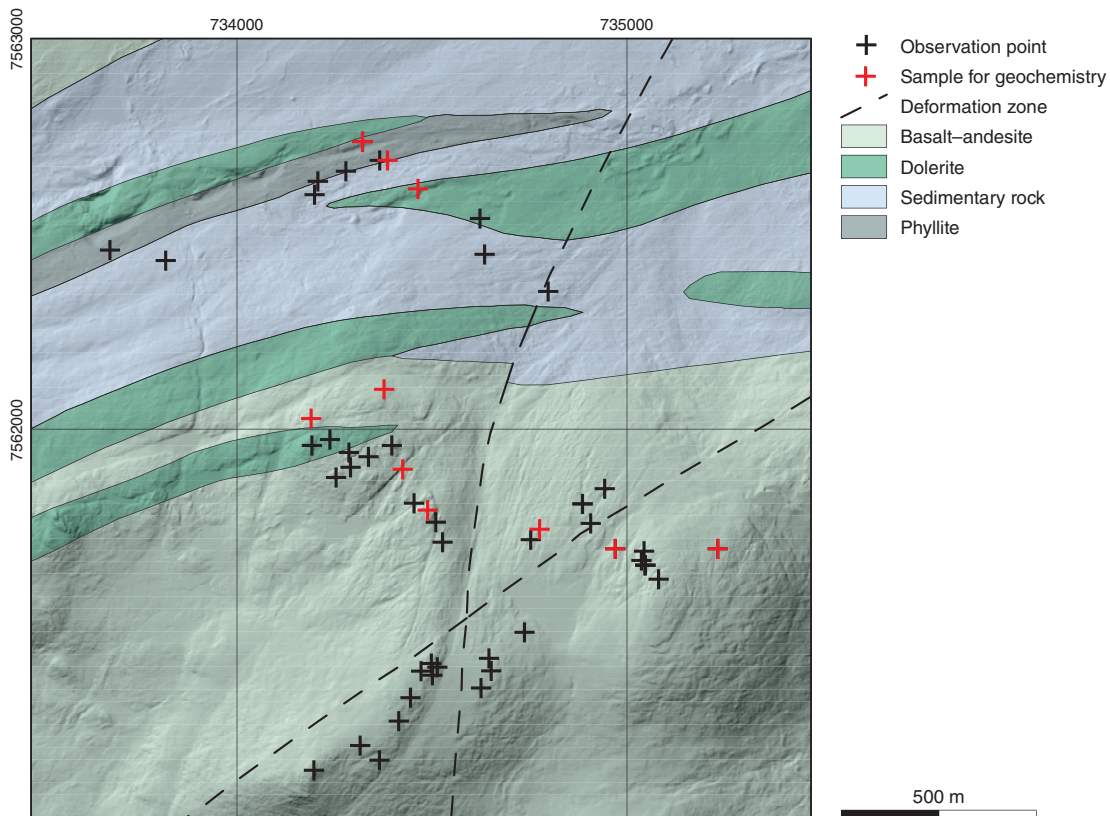


Figure 10. Observations and sampling locations in the eastern part of the Vittangivaara key area.

observed deformation pattern.

Eastern Vittangivaara

On the eastern side of the Vittangivaara key area the bedrock is very well exposed allowing for detailed sampling and mapping of structures within the Kiruna greenstone group (Fig. 10). Field work was also carried out on mount Vittangivaara, which is located just east of the key area (see Fig. 2), with the purpose of better constraining the lateral continuation of the different rock types and structures.

Stratigraphy

The lower part of the stratigraphic succession in the Vittangivaara area has been sampled on the northern flanks of the mountain and it consists mainly of shallow, southward dipping volcanic tuffs with intercalated metasedimentary rocks. Based on the stratigraphy of the Kiruna greenstone group established by Martinsson (1997), these rocks can be considered as part of the Viscaria formation. The tuffs comprise thin and continuous layers that consist of both mafic and felsic material (Fig. 11a). The exact composition of these beds should be further studied under the microscope and using litho-geochemistry. Some of the layers are truncated by syn-sedimentary normal faults (Fig. 11a). In addition, the entire unit has been cross-cut by several fracture sets, which appear on a millimetre scale (fig. 11b) as well as on a metre scale (fig. 11c). Along the north-south trending fractures, sub-horizontal striations were frequently observed.

Higher up in the stratigraphy the tuffs are intruded by several fine- to medium-grained dolerite sills that are parallel to the bedding. These sills are more resistant to erosion than the



Figure 11. **A.** Tuffite in the Viscaria formation of the Kiruna greenstone group showing alternating sandy layers of felsic (light coloured) and mafic (dark coloured) composition. Notice that a syn-sedimentary normal fault to the left governed the layer thickness (7563119/738420, slh131006). **B.** Tightly spaced sub-vertical fractures orthogonal to bedding which dips gently towards the south-west (7562689/734386, slh131020). **C.** Set of sub-vertical, north–south trending fractures showing only minor vertical displacements (7562661/734279, slh131021).

surrounding tuffs, which make them recognizable on the LiDAR elevation maps. In the vicinity of the topographic highs, mafic to ultramafic rocks appear, which belong to the Peuravaara formation (Martinsson 1997). Most of these basalts are again strongly fractured, predominantly by a set of north-north-east trending sub-vertical fracture planes (Fig. 12a). Bedding planes were mostly recognized by the presence of pillow lava structures, of which the light-coloured altered rims stand out and sometimes reveal dextral shearing (Fig. 12d). The macroscopic texture of the basalts reveal only a low to moderate degree of alteration, which mostly consists of albitization associated with veins and fractures (Fig. 12c).

Structural observations and interpretations

Certain structures within the area of interest were already reinterpreted before conducting the fieldwork. Moreover, the high resolution elevation model (LiDAR) was used to carefully select some interesting structural features, which were then further studied in the field. As such, the field study focused on what appears on the elevation data as a large fold hinge, which is intersected by escarpments that may parallel an axial plane cleavage (Fig. 13a). Field measurements support the preliminary fold-interpretation. The bedding planes within the two rock formations show a variation from east-north-east-striking to west-north-west-striking (Fig. 13a). Stereonet



Figure 12. **A.** Abundant north–south trending fractures are easily recognised in the landscape and form up to three metre high escarpments (7561897/734425, slh131029). **B.** Bedding plane dipping gently to the south in the Peuravaara formation of the Kiruna greenstone group (7561810/734454, slh131028). **C.** Slightly rotated tension gashes filled with quartz and albite (7561810/734454, slh131028). **D.** Sheared and altered rim around a pillow lava indicating dextral shear (7561897/734425, slh131029).

plots reveals a fold-axis that plunges towards the west-south-west (Fig. 13a). It was also confirmed that a steeply dipping axial plane cleavage strikes constantly towards the NE and parallels indeed the escarpments. In addition, the southeastern fold limb is intersected by two major faults, which probably accommodated dextral displacements (Fig. 13b).

Regional interpretation

A regional interpretation that includes the observations from Vittangivaara is largely based on an integration of geological observations and airborne magnetic data (Fig. 14). Here, the synclinal fold structure described in the previous section extends all the way to Vittangivaara. It is clear that the observed rock types in these areas are indeed comparable. The extrapolation between both areas, however, is not consistent. In fact, a low magnetic anomaly, which relates to the fold hinge region, strikes towards lake Vittankijärvi. This interpreted dismembering of the fold hinge could have occurred along a dextral displacement zone, which consist of several duplexes (Fig. 14). Along these duplexes the magnetic anomaly is again higher. This indicates that the sequence of folding and faulting is an important input in any attempt to derive a large-scale regional tectonic model for the area using local observations.

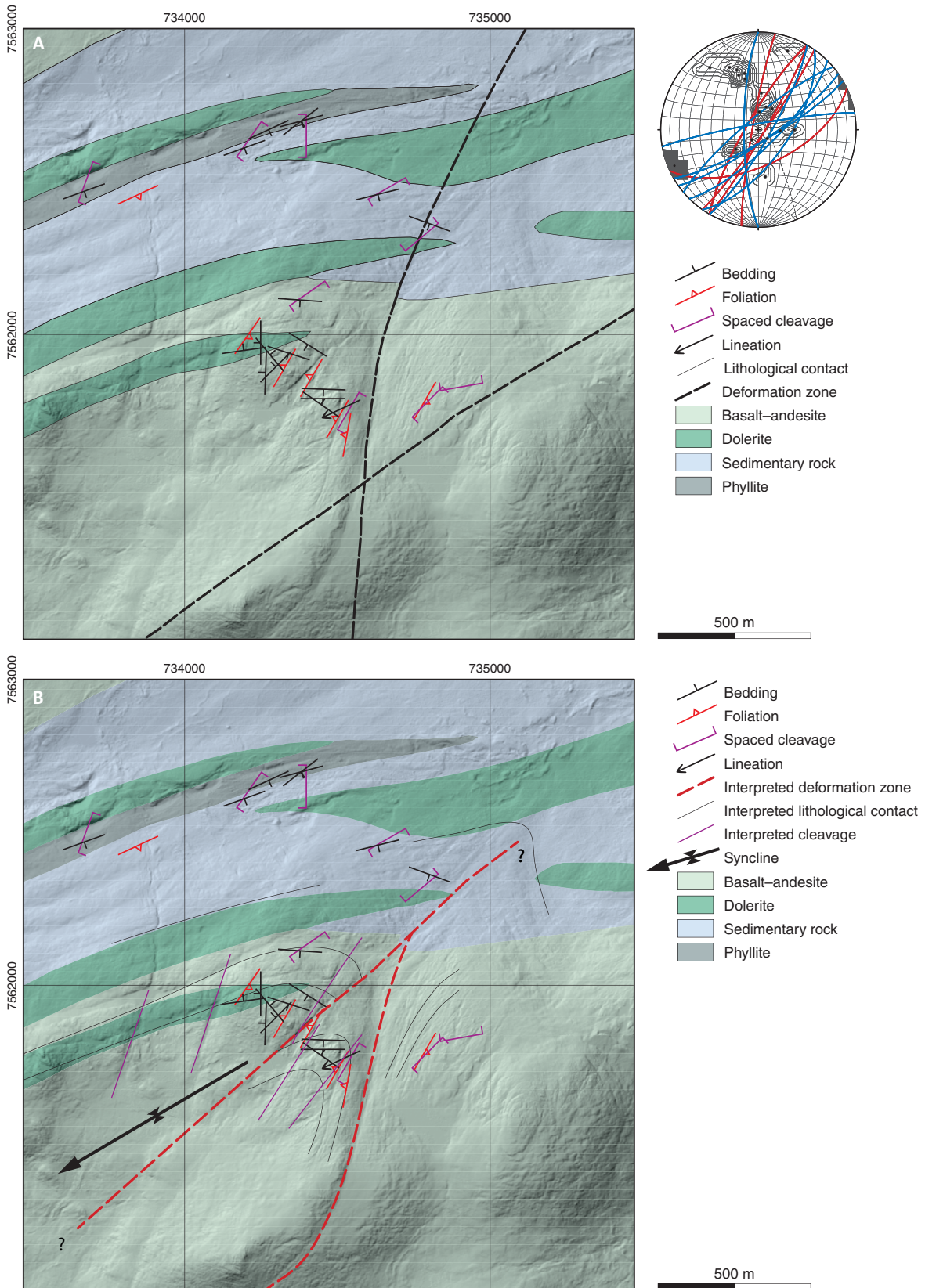


Figure 13. **A.** Structural measurements within the eastern Vittangivaara area plotted on the geological map and as great circles in a lower hemisphere stereogram (upper right). The Lidar map is shown in the background. **B.** Revised structural interpretation based on new observations and the Lidar map.

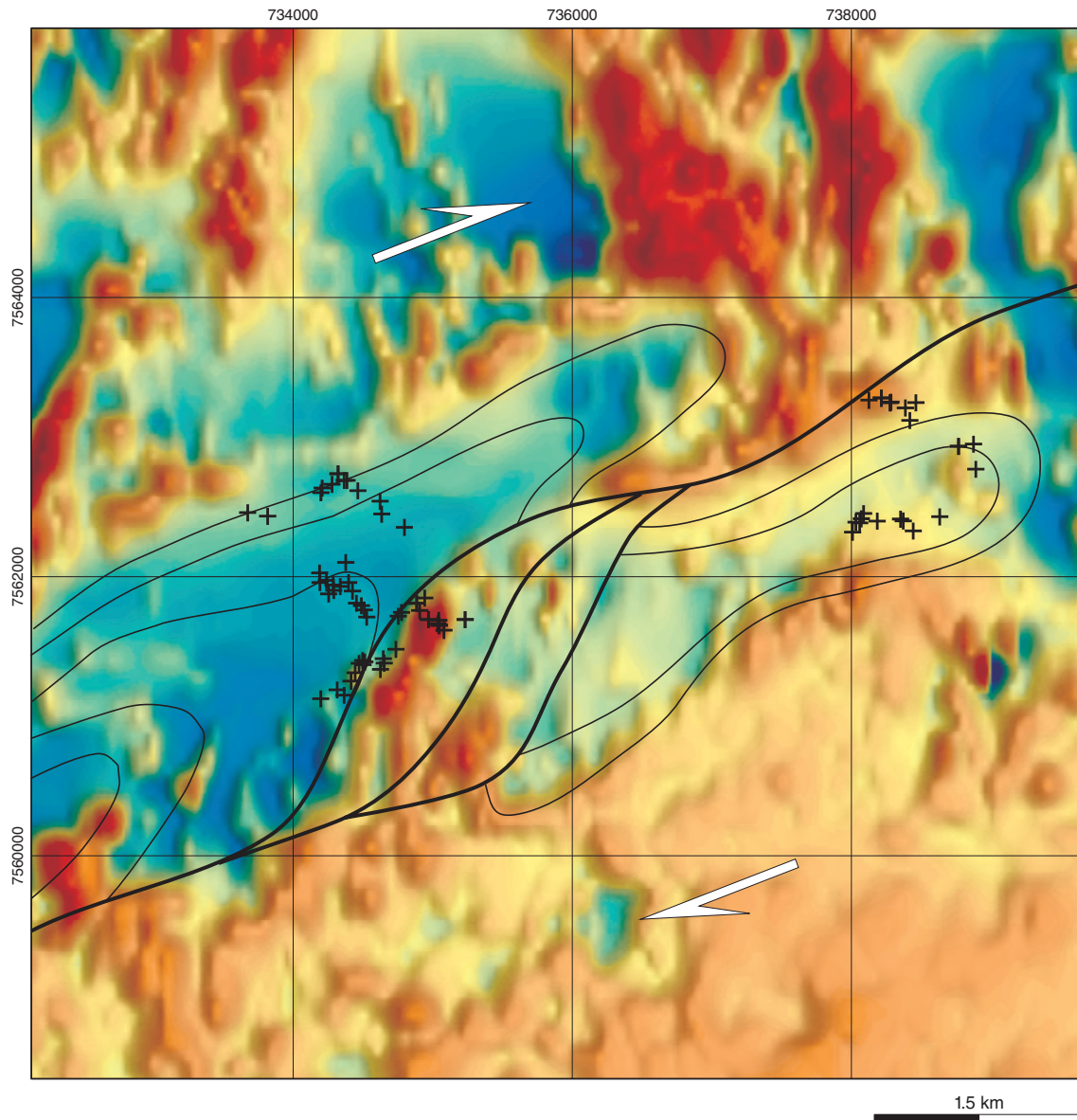


Figure 14. Structural interpretation based on new geological observations and the magnetic anomaly map. The syncline has been associated with a magnetic low (blue) and is dextrally dismembered (see text for more details).

AKKISKERA-KUORMAKKA

The main purpose of the study in the Akkiskera-Kuormakka area was to look for structural features corresponding to the Karesuando-Arjeplog deformation zone (KADZ, e.g. Luth & Berggren 2013). The observation and sampling points are clustered in the western side of the area as well as along the east–west road where outcrops are most abundant (Fig. 15). Mapping was conducted along three minor (<1 km) and one major (6 km) north–west trending profiles, which are orthogonal to the stratigraphy and main foliation. Along these profiles a strong variation in lithology, degree of deformation and degree and type of alteration was observed. It seems that most of the deformation was accommodated by a 10–20 m thick mylonite zone, whereas alteration mostly affected the rocks located east of this zone.

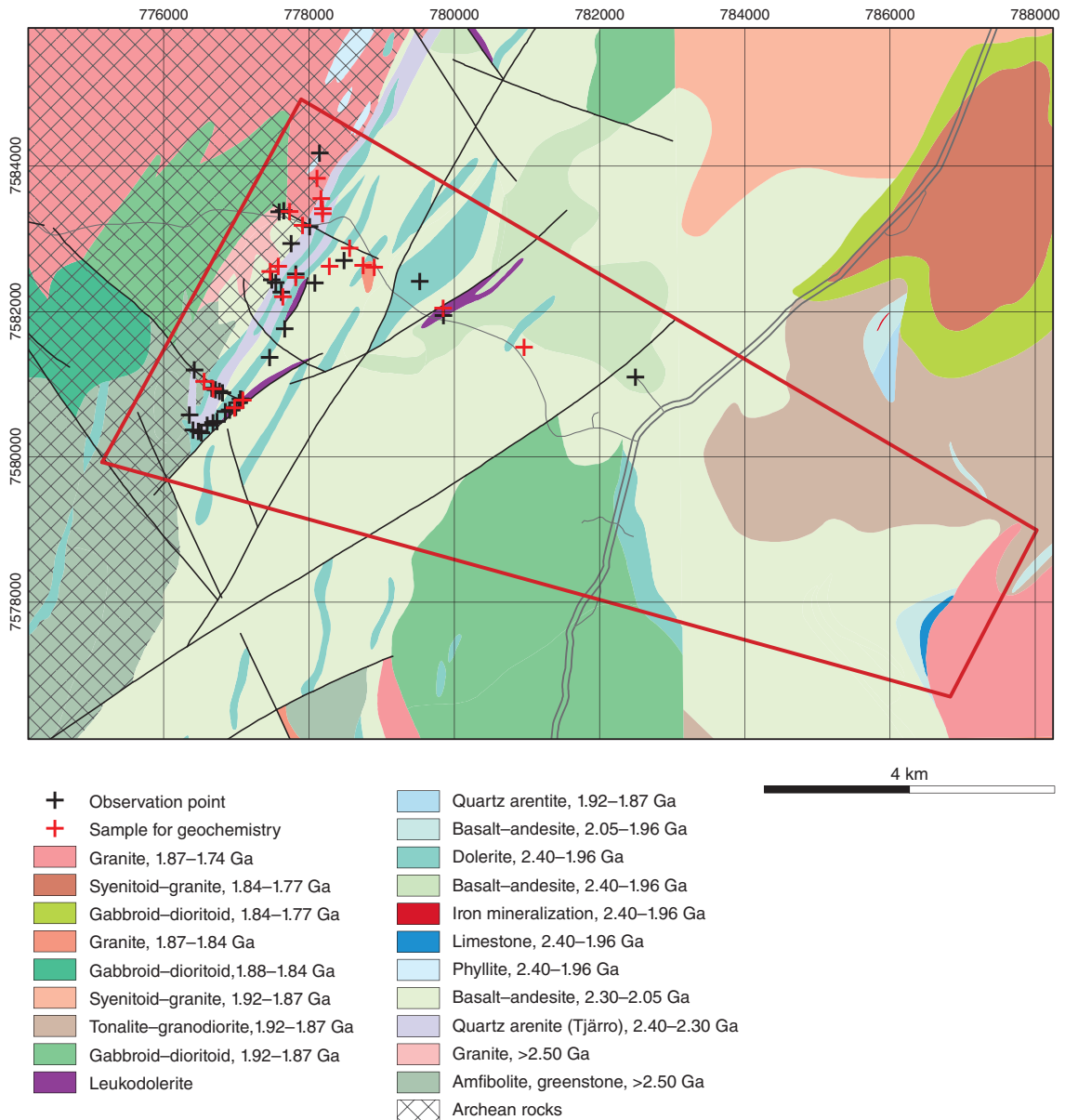
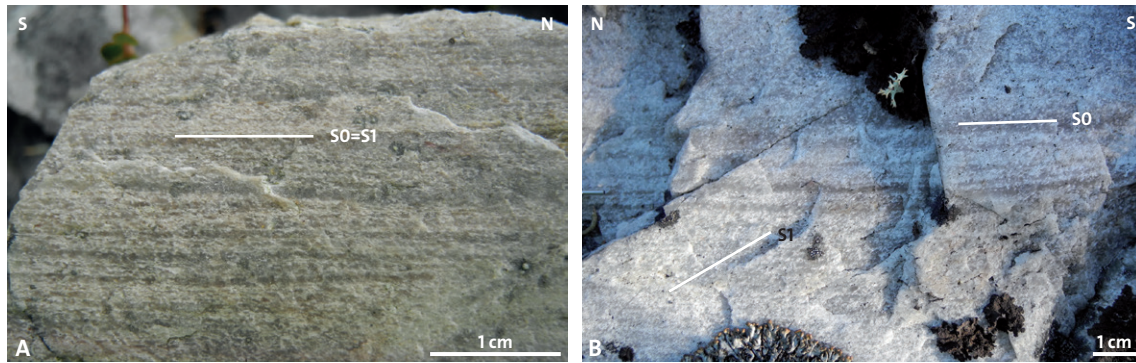


Figure 15. Observations and sampling locations in the Akkiskera-Kuormakka key area.

Stratigraphy

The rock types found in the westernmost region include medium- to coarse-grained granites and fine-grained andesites. These rocks were earlier interpreted as part of the Archean basement (Råstojaure complex), whereas the pinkish granites in the north-western corner was considered to be Paleoproterozoic (Perthite-monzonite suite). However, age determinations are few and new geochronology is ongoing in the area.

The Archean basement is overlain to the east by a feldspar-rich quartzite (Tjärro quartzite), which contains a strong foliation that trends mostly parallel to the bedding (Fig. 16a). The lower contact was not observed, but was interpreted to within a few tens of metres. Conglomerates along the contact reported by Kumpulainen (2000) were not found during this study. In contrast, a mylonite zone was found which confirms that the contact between the Archean



Figur 16. Tjärro quartzite. **A.** Bedding and foliation are often parallel (7583167/778011, slh131082). **B.** Bedding at an angle of 40° to foliation (top-view). The bedding is characterised by an alternation of transparent (quartz-rich) layers and white, feldspar-rich layers. Notice the low-angle cross-bedding indicating younging towards the east (7582394/777547, slh131110).

basement and quartzites is tectonic (see Luth & Berggren 2013). Within the quartzites, it was not always possible to distinguish between bedding and foliation, but in general the bedding is characterised by an alternation of transparent, quartz-dominated layers and milky-coloured, feldspar-rich layers (Fig. 16). Elongation of individual feldspar grains defines the foliation, which when oriented at an angle to the bedding occurs parallel to a spaced cleavage (Fig. 16b). In strict terms the recognition of individual grains should not be possible within a quartzite, making this rock more a quartz-rich arenite or an arkose. Low-angle cross-bedding indicating younging towards the east was recognised despite the penetrative foliation (Fig. 16b). The thickness of the quartzite unit ranges between 300 and 400 m and seems constant throughout the area, with an exception in the south-west. Here, the unit bends towards the north along a drag fold of which the western limb was thinned to only a few metres.

Directly east of the Tjärro quartzite is a well exposed, highly magnetic, medium-grained dolerite (Fig. 17a). The rock consists of euhedral amphibole and pyroxene and anhedral albite. Both field observations and interpretations from the magnetic anomaly maps suggest that this 100–200 m thick dolerite is parallel to the quartzite unit within the entire area. Its lower contact with the Tjärro quartzite was not observed, but constrained to within a few metres. Magma intrusion along this contact led to local contact metamorphism observed in the upper parts of the quartzite (Fig. 17b). The upper contact of the dolerite (basalts of the Kiruna greenstone group) has not been documented in this field study, but it seems that the basalts near the contact zone have been intruded by several smaller and laterally less continuous dolerite sills (Fig. 15).

Gabbroic rocks observed further to the east (Fig. 17c) have a similar mineralogy to the dolerite intrusions, and both the dolerite and the gabbro may therefore relate to the same magmatic event. However, the albite content seems to be higher in the dolerite sill, which may be a result of alteration (see below). Furthermore, in a few outcrops along the east–west road, the gabbro intrusions contained fragments of basalt as well as irregular veins and patches of pegmatite. To the east, the volume of intrusive rocks decreases and basalt is the dominant rock type. This basalt is a dark-coloured, fine-grained rock and it is often rich in amygdules, which are mostly filled with biotite and contain rims of feldspar.

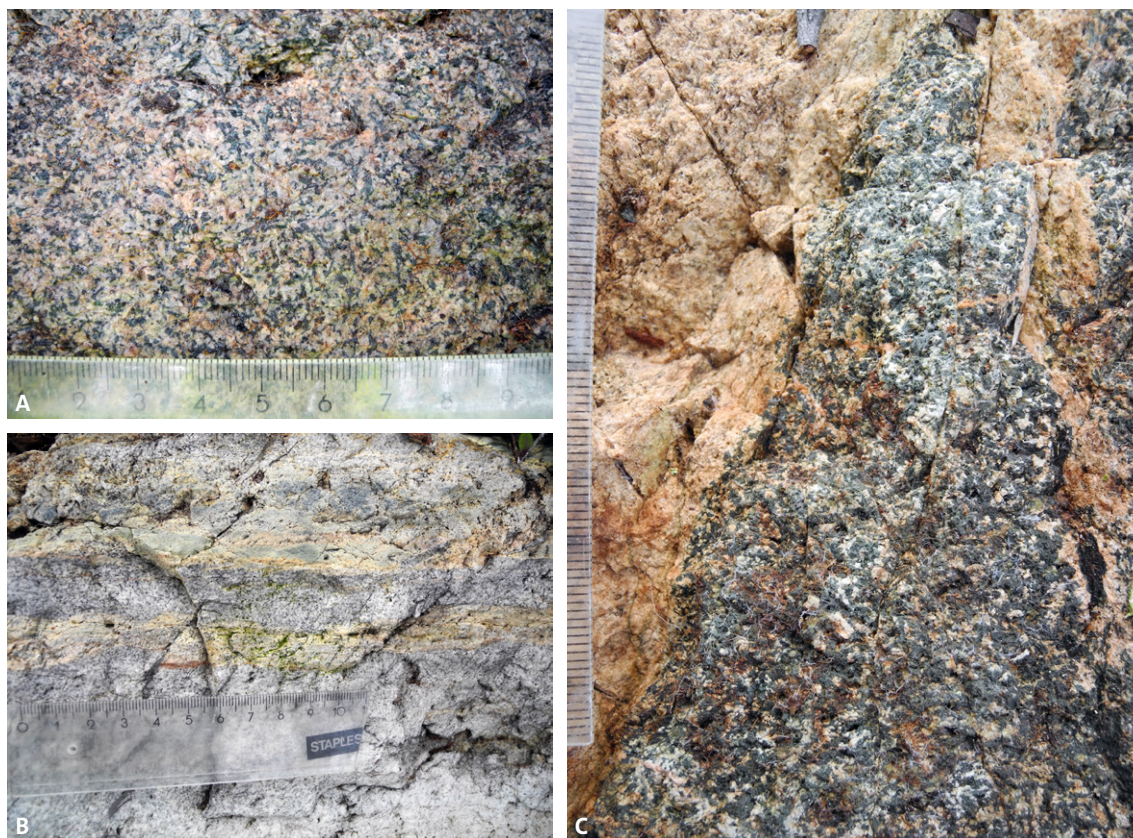


Figure 17. **A.** Intermediate dolerite (magnetic, susc. 5000 SI) overlying the Tjärro quartzite to the east (7583343/778192, slh131086). **B.** Tjärro quartzite within 1 m of the contact to the dolerite sill underwent alteration (greenish and pinkish bands of unknown composition). The altered bands are dextrally sheared and sub-parallel to layering and foliation (7583343/778192, slh131087). **C.** Intermediate dolerite transitions toward the east into a gabbro (locally pegmatitic) which has been intruded by a felsic and pegmatitic rock (7582605/778901, slh131107).

Structural observations

Detailed profile mapping revealed a sub-vertical, north-north-east trending, penetrative foliation affecting both the Tjärro quartzite and the (sub)volcanic rocks to the east (Fig. 18). Most of the deformation was localised along steeply dipping, north-north-east trending shear zones. Several of these zones are located within the Archean basement and C-S fabrics indicate both sinistral and dextral lateral displacements (Fig. 19a–c). Other shear indicators, such as rotated clasts and a large-scale drag fold in combination with moderately south to south-west plunging stretching lineations, imply dextral transpression. Intense deformation was also accommodated by the overlying sedimentary rocks as indicated by the development of a very strong continuous foliation. Observations on a 50 m thick, vertical mylonite zone, however, suggest that most deformation was accommodated along the contact between the Archean basement and the Tjärro quartzite (Fig. 19d). The observed shear indicators in this mylonite zone (rotated and broken feldspar clasts) indicate east-side-up movement. No surface allowed for the field observation of a possible lateral slip component, but this may be revealed in thin-sections. Further towards the east, the degree of deformation decreases as expressed by a weakly developed foliation and open folding within the dolerites, gabbros and overlying basalts. An exception to this is the presence

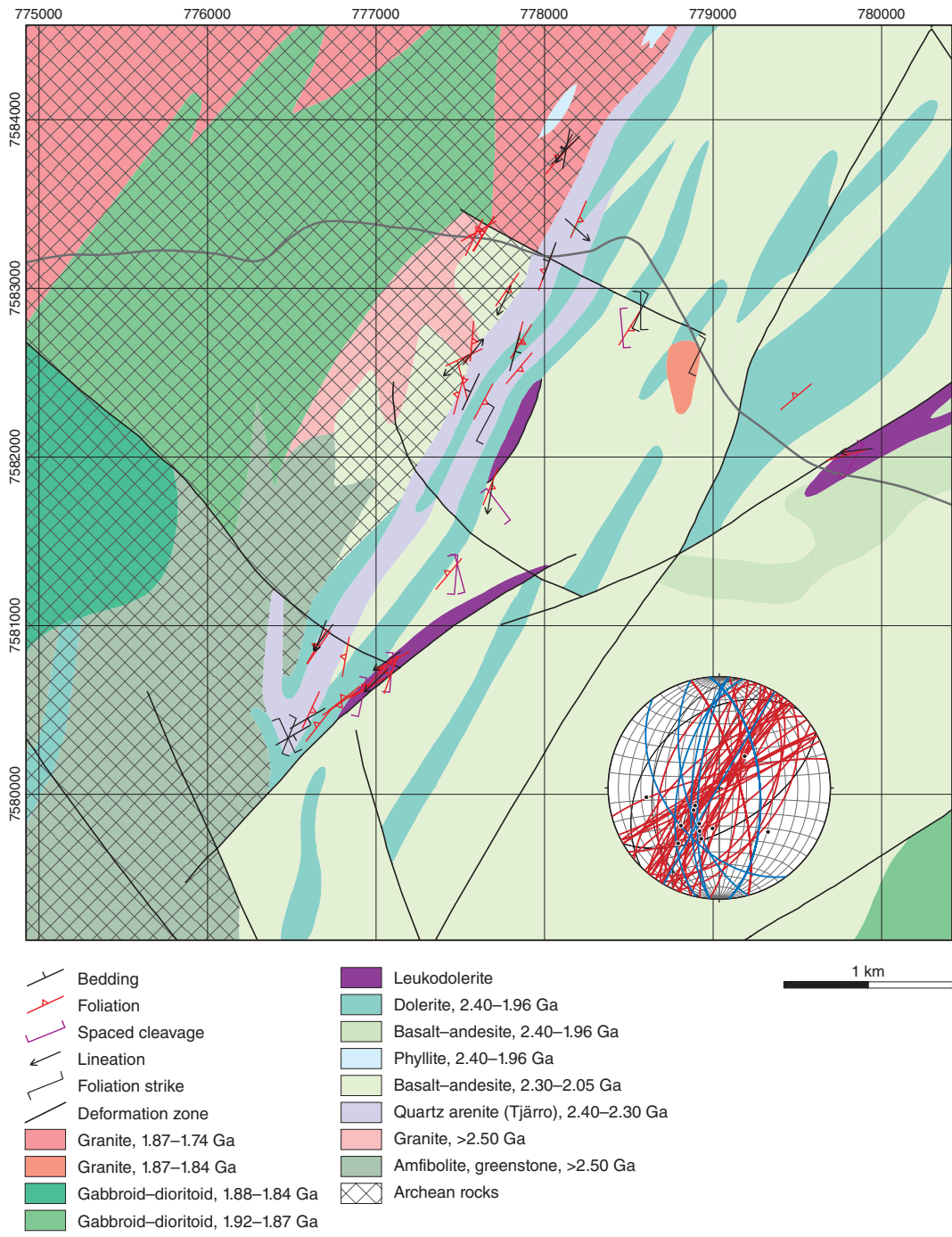


Figure 18. Structural measurements within the eastern part of the Akkiskera-Kuormakka area plotted on the geological map and as great circles in a lower hemisphere stereogram (lower right). Notice the drag folding of the Tjärro quartzite (light blue) in the lower left.

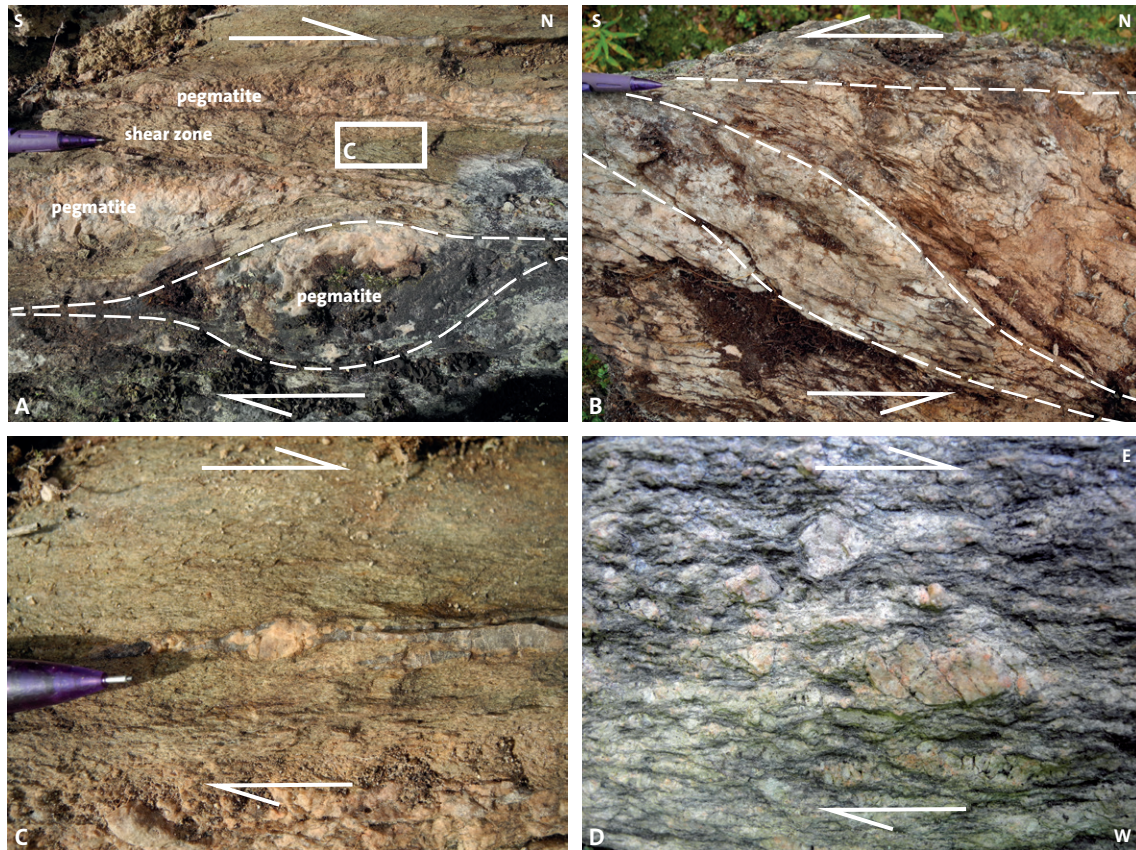


Figure 19. **A.** Shear zones in pegmatitic and granitic rock, possibly Archean basement, with dextral strain indicators (7583551/778169, slh131088). **B.** Shear zone in pegmatitic and granitic rock, possibly Archean basement, with sinistral strain indicators (7583387/777656, slh131084). **C.** Shear zone in pegmatitic and granitic rock with dextral strain indicators (7583551/778169, slh131088) **D.** Mylonite along the contact between the Archean basement and the Tjärro quartzite. Rotated and broken feldspar clasts indicate east-side-up movement (7582621/777581, slh131097).

of north-north-east trending semi-brittle fault zones along which the rocks are often foliated, brecciated and intersected by quartz, albite and carbonate veins.

Interpretation of the alteration pattern

The type and degree of alteration that affected the rocks in the Akkiskera-Kuormakka area varies within the region. A general decrease in alteration from the west towards the east (perpendicular to the main foliation) has been observed. Alteration is also weaker in the Archean basement and mylonite zone. Alteration is most severe directly east of the Tjärro quartzite affecting the overlying dolerites (Fig. 20). Here, the high albite content in the matrix may indicate a pervasive alteration, whereas a K-feldspar and epidote alteration is mostly restricted to veins (Fig. 20c). In some places the entire rock has been albitized (Fig. 20b). In the overlying basalts, K-feldspar alteration affected mainly the basalts that are located within 1 km of the main mylonite zone or in the vicinity of brittle faults. Further to the east, the observed alteration was restricted to some scapolitisation affecting the basalts of the Kiruna greenstone group. Lithogeochemical analysis, in combination with thin section studies, will be used to verify and extend these field observations.

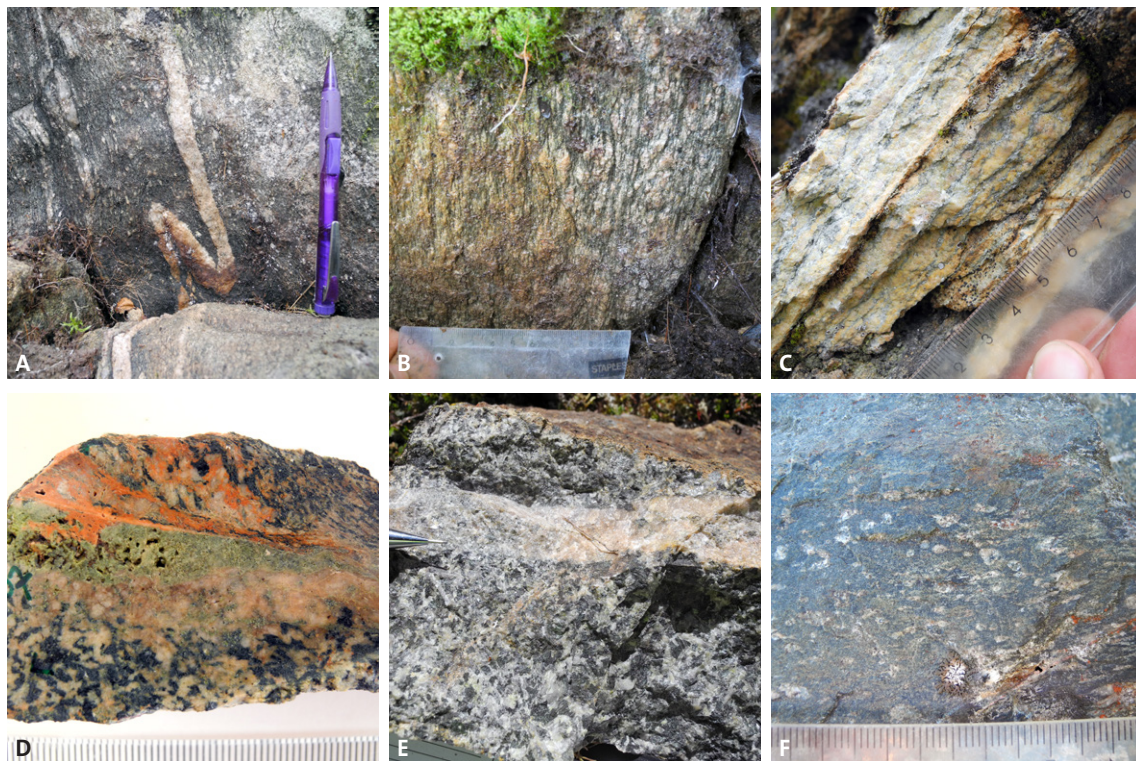
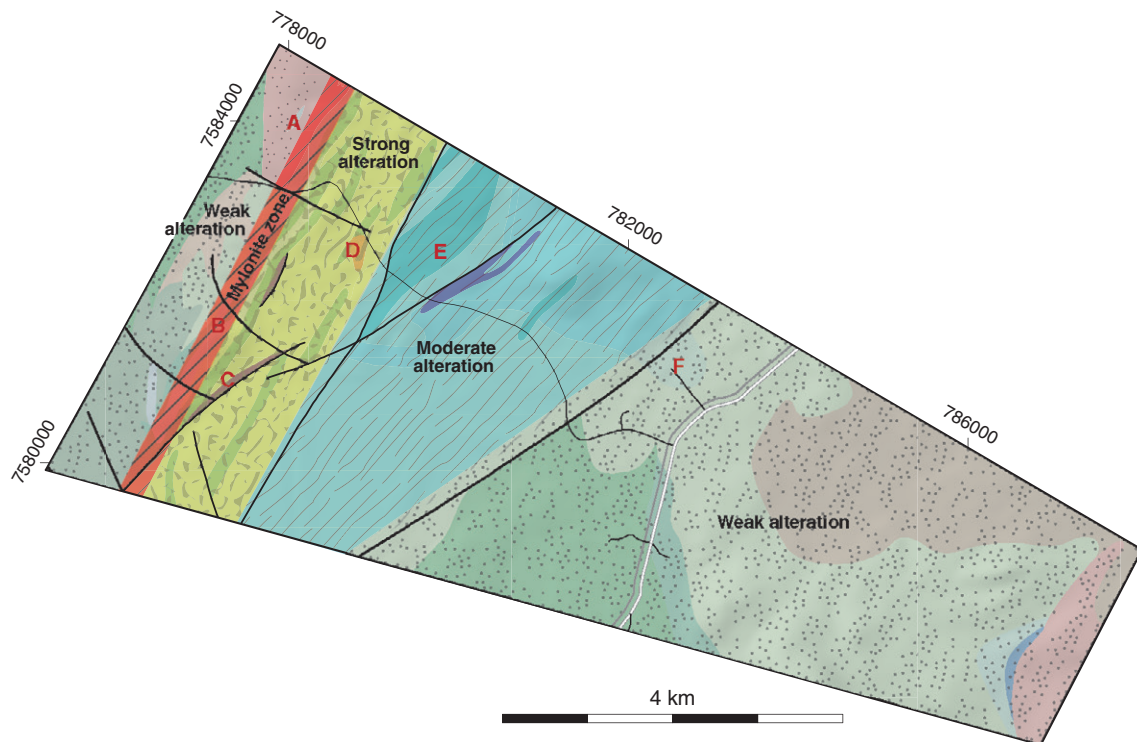


Figure 20. Preliminary rock alteration map based on the new field observations from the Akkiskera-Kuormakka area. Alteration is only minor in the Archean basement and mylonite zone (A–B), but is most severe directly east of the mylonite zone. C. Albite dolorite. D. Veins of K-feldspar and epidote in intermediate dolorite. Further towards the east, gabbros and the basalts of the Kiruna greenstone group (E–F) underwent only moderate to minor alteration.

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