Gold mineralisation at Eqi, north-east Disko Bugt, West Greenland

Henrik Stendal, Christian Knudsen, Mogens Marker and Bjørn Thomassen

Gold mineralisation at Eqi, north-east Disko Bugt, West Greenland, is hosted in Archaean (*c.* 2800 Ma old) supracrustal rocks; the latter are divided by a thrust into a lower volcanic unit and an upper sedimentary and volcaniclastic unit. The lower volcanic unit comprises three parts: a basal pillowed greenstone sequence, an acid volcanic complex, and an upper mafic igneous complex.

Intensive hydrothermal activity resulted in extensive carbonatisation and sericitisation, which is most intense just above a system of acid feeder dykes within the basal greenstone sequence. Primary enrichment in gold took place during pervasive hydrothermal alteration, and the gold is mainly located in carbonate-altered rocks. Remobilisation of gold occurred during formation of later quartz veins in the altered zone; these quartz veins have gold contents of up to 60 ppm.

The geological setting, geochemistry and formation of the gold mineralisation at Eqi is similar to many Archaean gold deposits in the Abitibi belt of Canada.

H.S. & M.M.*, Geological Institute, University of Copenhagen, Øster Voldgade 10, DK-1350 Copenhagen K, Denmark. *Present address: Geological Survey of Norway, Leiv Eirikssonsvei 39, N-7491 Trondheim, Norway. E-mail: *henriks@geo.geol.ku.dk.*
C.K. & B.T., Geological Survey of Denmark and Greenland, Thoravej 8, DK-2400 Copenhagen NV, Denmark.

Discovery of gold anomalies by the Geological Survey of Greenland (GGU) in north-east Disko Bugt in 1988 at what later became known as the 'Eqi East Prospect', was followed by further exploration by Platinova Resources Ltd – Faxe Kalk A/S in 1989–1991 (Knudsen & Nielsen 1992) and GGU in 1991. This paper presents an overview of the current knowledge of the mineralisation, and suggests a genetic model. It is based on field work undertaken on the prospect by GGU and the Platinova – Faxe Kalk joint venture, as well as reports by Kryolitselskabet Øresund A/S on the 'Eqi West Prospect' (Gothenborg & Keto 1986).

Regional geological mapping in the north-eastern part of the Disko Bugt area was carried out by GGU in 1964 (Escher & Burri 1967) and continued in the years 1987 to 1991 (Knudsen *et al.* 1988; Kalsbeek & Christiansen 1992; Steenfelt 1992); regional mineral exploration was carried out by Kryolitselskabet Øresund A/S in 1980–82 (Gothenborg & Keto 1986), and by Platinova Resources Ltd – Rayrock-Yellowknife Resources Inc. in 1988 (Blackwell 1989).

Geology of the Eqi area

The Eqi area consists of Archaean granitoid rocks, gneisses and units of supracrustal rocks (Garde & Steenfelt 1999, this volume) which are unconformably overlain by early Proterozoic supracrustal rocks of the Anap nunâ Group. The Archaean supracrustal sequence is dated at *c.* 2800 Ma (Kalsbeek & Taylor 1999, this volume).

In the Eqi area (Fig. 1) Archaean supracrustal rocks are in tectonic contact with Archaean migmatitic
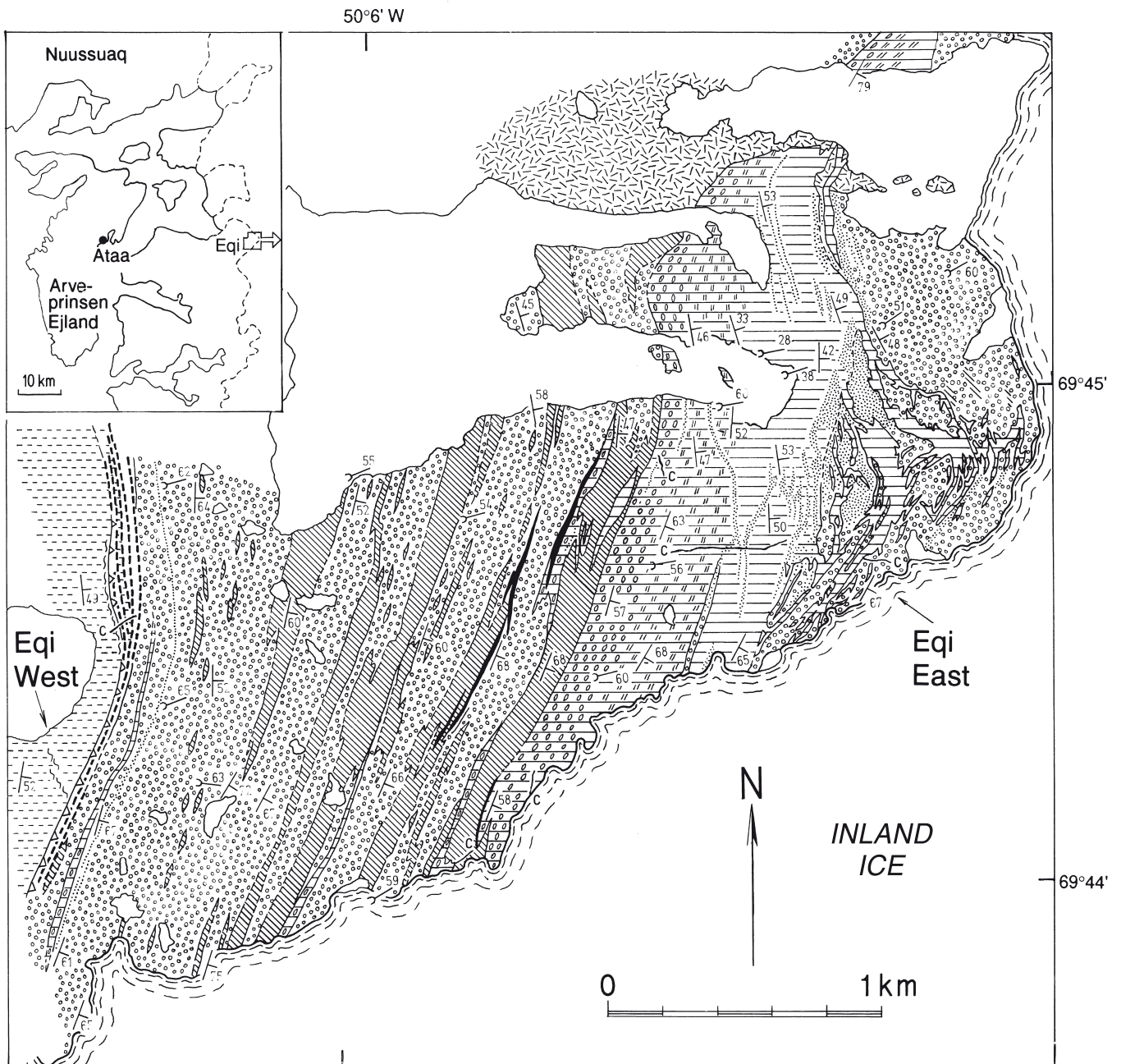
Fig. 1. Geological map of part of the Eqi area.

gneisses and variably foliated non-migmatitic granitoid rocks containing occasional layers of amphibolite. Granitoid sheets, probably related to the 2800 Ma Atâ tonalite (Garde & Steenfelt 1999; Kalsbeek & Skjernaa 1999, both in this volume) intrude the supracrustal rocks. The interleaved granitoid and supracrustal rocks are highly strained and form a conspicuous layered rock unit below an eastward-dipping thrust contact with the supracrustal sequence to the east (see geological maps of Garde 1994 accompanying this volume, and Escher 1995).

Stratigraphy

The Archaean supracrustal sequence at Eqi can be divided into an eastern succession dominated by basic meta-igneous rocks, with an important acid igneous complex in the central part of the sequence, and a western succession of metasediments and volcaniclastic rocks with subordinate intercalations of basic rocks. The eastern and western successions are separated by a thrust which dips eastwards at 50–70°, parallel to the schistosity (Fig. 1). There are also thrusts in the western succession, which converge southwards towards a boundary thrust which forms the contact with the gneisses. The thrust between the two successions coincides with a marked change in metamorphic grade, greenschist facies in the east and amphibolite facies in the west. Five kilometres to the north-west the continuation of the thrust is obscured by unconformably overlying conglomerates which form the basal part of the early Proterozoic Anap nunâ Group (Garde & Steenfelt 1999, this volume). Only the eastern Archaean succession is discussed in detail here.

Basic igneous complex. The eastern succession of supracrustal rocks is at least 3–4 km thick and consists mainly of greenschist facies pillow lavas intruded by sheets of metagabbro (Fig. 1). Primary features of the pillow lavas are often well preserved, and from the packing structure of the pillows a westward-younging direction can be determined. This suggests that the supracrustal sequence at Eqi is inverted with its lowermost part located towards the east where it is hidden beneath the Inland Ice.

Acid igneous complex. The middle part of the eastern greenstone succession contains a conspicuous unit of acid igneous rocks, interpreted as a rhyolitic dome complex. The complex is several kilometres long and

up to 1 km thick (Fig. 1), and is dominated by quartz and feldspar porphyries. Its lowermost part rests on the lower pillowed greenstone succession and consists of massive rhyolitic rocks capped by a schistose sericite schist which grades upwards into an agglomerate of closely packed fragments. The schistose zone appears to have a tectonic origin since it is discordant to the bedding of the rhyolites. The agglomeratic part of the sequence consists of stretched, closely packed, rounded, elongated fragments of whitish to light grey porphyry with scattered 1–4 mm large phenocrysts of quartz and plagioclase. The matrix between the fragments also contains quartz and plagioclase. A network of rhyolitic dykes in the underlying greenstones is interpreted as a feeder dyke system to the rhyolite dome complex. The lower massive part as well as the feeder dykes consist of homogeneous light grey porphyry with scattered phenocrysts of quartz and plagioclase.

Metasedimentary rocks. At several levels within the volcanic sequence there are thin discontinuous layers of black graphite phyllites. Thin layers of banded iron formation also occur locally, the first immediately above the main acid body. The metasediments are generally overlain by greenstones. Extensive layers of banded iron formation occur in the uppermost part of the eastern greenstone-dominated succession where they are hosted in a 20–50 m thick unit which consists of layers of metasediment and acid volcanics, each up to 2–4 m thick.

Dolerite. The northern part of the acid igneous complex at Eqi is cut by a large body of black metadolerite (Fig. 1). The rock is locally deformed and strongly altered, and it is presumably of Archaean age.

Late carbonate-rich dykes. Several carbonate-rich dykes occur within the supracrustal rocks. They generally trend E–W, N–S or NE–SW (Fig. 1). They are up to 1 m thick and post-date the main deformation and shearing, but locally they are folded into open folds, possibly by passive folding during late flattening. The dykes are composed of fine-grained carbonate (75–85%), quartz (3–15%), muscovite (0–15%), chlorite (0–6%), opaque minerals (1–2%) and accessory titanite. The age of these dykes is unknown.

E–W-trending suites of ultramafic lamprophyre dykes, often with carbonate-rich centres, are widespread in the Archaean gneisses (Marker & Knudsen 1989). These dykes differ from the carbonate-rich dykes in the supracrustal sequence in that they have a differ-
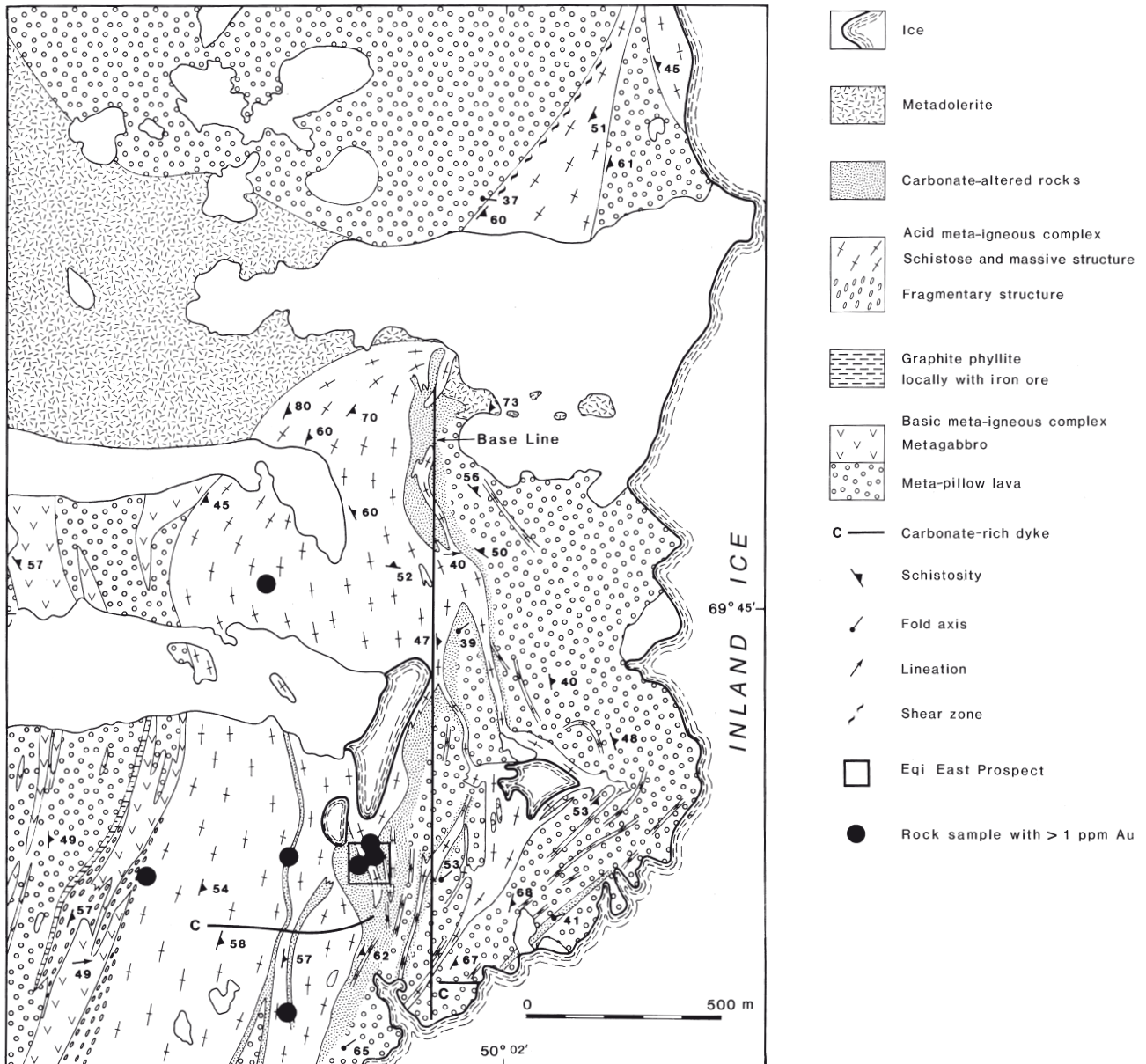
Fig. 2. Simplified geological map of the eastern Eqi area.

ent composition, commonly with igneous phlogopite preserved, and they give rise to strong contact alteration in the gneisses. The age of the lamprophyres is c. 1750 Ma (Larsen & Rex 1992; Rasmussen & Holm 1999, this volume).

Hydrothermal alteration

Hydrothermal alteration associated with extensive carbonatisation and local sericitisation, chloritisation and pyritisation affected the boundary area between the lower part of the acid volcanic complex and the underlying pillowed greenstones (Figs 1, 2). During hydrothermal alteration both acid and basic rocks were affected, often to such a degree that it can be difficult to determine whether the protolith was basic or acid. The acid feeder dyke system also shows evidence of an increasing degree of hydrothermal alteration towards the base of the acid volcanic sequence.

According to Knudsen et al. (1990) and Knudsen & Nielsen (1992) two main types of carbonate-altered rocks were formed successively: (1) massive carbonate-altered rocks with desilicification structures giving rise to thin (<5 cm) quartz veins, and (2) schistose carbonate-altered rock rich in sericite. Within both types

of carbonatised rock microjoints are filled with dark green chlorite, sericite, green mica (fuchsite?) and pyrite. A widespread product of the hydrothermal carbonate alteration is a graphitic, green mica- and chlorite-bearing ankerite rock with an irregular network of quartz veins, up to 1 m wide (Fig. 3). Tiny prisms of accessory black tourmaline are common in the altered rocks and in minor shear zones. Some tourmaline is also present in quartz ankerite veins.

Metamorphism

The rocks of the eastern supracrustal succession at Eqi are metamorphosed to the (upper) greenschist facies. The meta-pillow lavas are rich in chlorite while metagabbros are rich in pale actinolitic amphibole. Both contain subordinate epidote. The acid meta-igneous rocks are rich in sericite or fine-grained muscovite generally making up to 10–25% of the rock. Epidote, chlorite, biotite and carbonate occur in accessory amounts outside the hydrothermally altered zones. The lower schistose and massive parts of the main acid body, the feeder dyke system and particularly the hydrothermally altered rocks frequently contain chloritoid, locally making up to 10–15% of the rock, possibly reflecting iron enrichment during hydrothermal activity.

Fig. 3. Carbonate-altered rocks with quartz veins. Coin for

Structure

The supracrustal sequence at Eqi shows evidence of one episode of penetrative deformation which culminated in thrusting. The eastern succession shows only minor tight to isoclinal fold structures while the overlying western succession has a large-scale isoclinal fold. A penetrative schistosity (S_1) is related to this deformation (D_1). S_1 is parallel to axial planes in isoclinal folds formed during D_1. Fold axes plunge 45–65° NE to ENE, parallel to a pronounced penetrative stretching lineation that possibly indicates thrusting towards the SW–WSW. Fold axes may have been reorientated during the thrusting. Strain indicators, i.e. pillows and acid fragments, indicate considerable stretching, and show that the original thickness of the Eqi sequence may have been much greater than seen today. The middle zone of the rhyolite dome complex is assumed to have been sheared contemporaneously with the thrusting elsewhere in the sequence. Since the rocks in question are unconformably overlain by undeformed early Proterozoic sedimentary rocks further to the north-west,
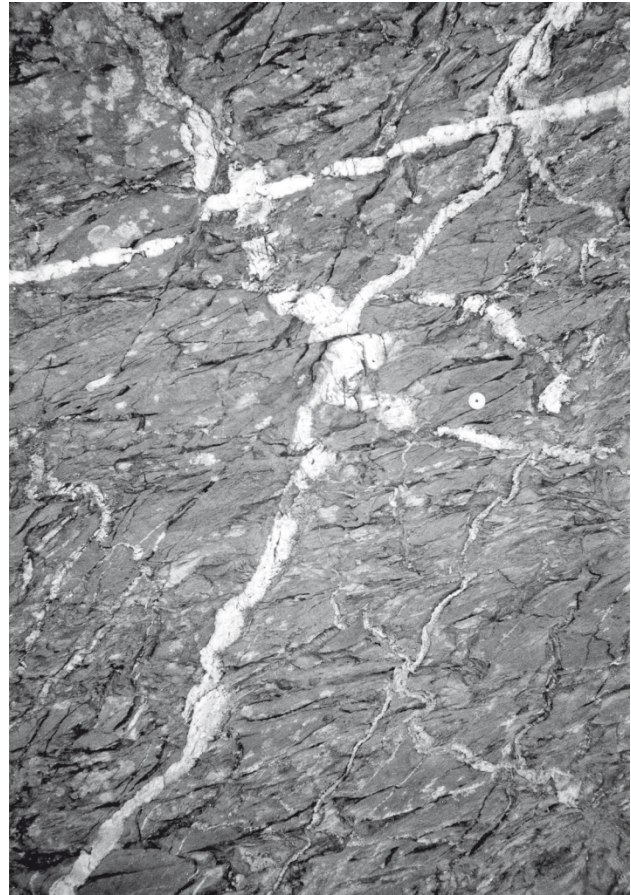
this dominant episode of deformation is inferred to be Archaean. Later deformation locally gave rise to an east–west steeply to vertically dipping fracture cleavage, locally developed as a schistosity, which may be associated with quartz filled tension gashes and small-scale open folds (amplitude <10 cm). Shear zones hosting gold-bearing quartz veins (Fig. 4) are probably related to this deformation.

Mineralisation

'Eqi West Prospect'

During the period 1980–82 Kryolitselskabet Øresund A/S carried out airborne and ground geophysical surveys, regional geological mapping, and percussion and diamond drilling on several localities with indications of copper mineralisation (Gothenborg 1983). Copper mineralisation was found along the western side of the thrust zone between the eastern and western Eqi successions. The mineralisation is hosted in concord-
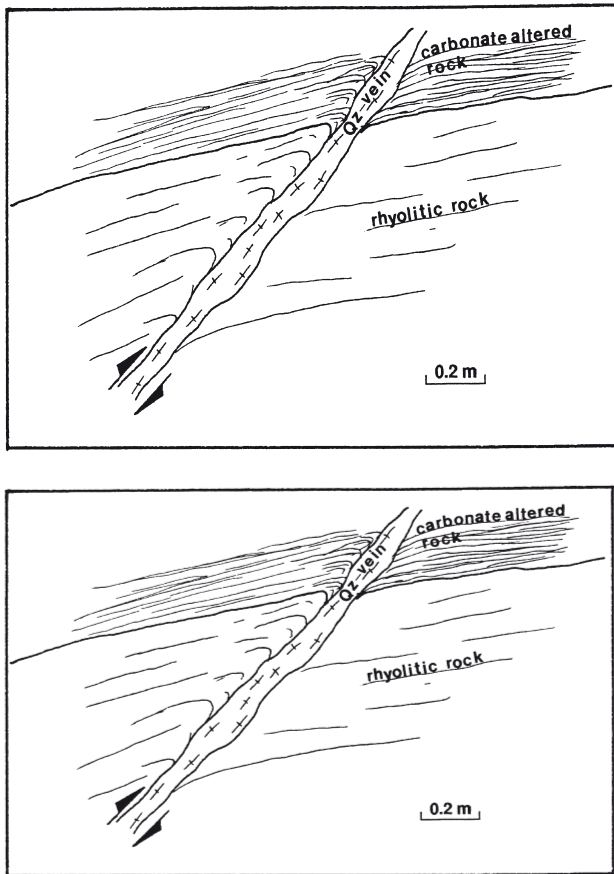
Fig. 4. Late quartz veins in small shear zones. From Knudsen & Nielsen (1992).

ant and discordant calcite, ankerite and quartz-cemented breccia zones in grey arenitic metasediments, a few tens of metres above the banded iron formation which marks the top of the metavolcanic unit. The age of the breccia zones is unknown.

The most promising occurrence, the 'Eqi West Prospect', comprises a discordant breccia zone up to 10 m wide, orientated 150°/80°NE, which outcrops over approximately 100 m. The zone consists of fragments of mica schist and phyllite cemented by calcite, ankerite, quartz, chlorite and sulphides. The predominant sulphide assemblage is pyrrhotite, chalcopyrite and pyrite with minor sphalerite, arsenopyrite, native bismuth and gold. The gold (electrum) contains 31% Ag (Sotka 1984). It occurs mainly as up to 100 µm large inclusions in chalcopyrite and occasionally in pyrrhotite. There is a strong positive correlation between the Au, Cu, Ag and Bi contents of the samples analysed. Nineteen grab samples from the prospect assayed 0.2–4.6% Cu averaging 0.84% Cu. The highest gold value obtained was 22 ppm and the best drill intersection as-

sayed 1.3% Cu and 12 ppm Au over 3.8 m corresponding to a true thickness of *c*. 2 m (Sotka 1984).

Four grab samples collected by GGU in 1991 from this breccia zone yielded a maximum of 13.5 ppm Au and 2% Cu. Knudsen *et al.* (1988) published chemical analyses for sulphide-bearing grab samples from the area and reported up to 12.3 ppm Au in a brecciated phyllite with carbonate and chalcopyrite veins.

Eastern Eqi area

Gold mineralisation (6 ppm Au in a 1 m chip sample) was found in the eastern Eqi area by GGU in 1988. In 1989 and 1990 prospecting and mapping was carried out by the Platinova – Faxe Kalk joint venture. Subsequent analysis of sulphide-bearing rocks yielded up to 60 ppm Au in a quartz vein grab sample (Knudsen *et al.* 1990). Detailed chip sampling was carried out by GGU and Platinova – Faxe Kalk in 1991 in the 'Eqi East Prospect' (Fig. 2), the area from where the highest gold values had been obtained previously (Knudsen & Nielsen 1992).

Most of the recorded gold was found by analytical means. Locally, however, visible gold occurs in blebs up to 20 µm across in pyrite (Knudsen & Nielsen 1992) and as small grains, a few micrometres in size, associated with carbonate and goethite, the latter probably formed by alteration of pyrite.

There are several types of sulphide mineralisation in the eastern Eqi area consisting mainly of pyrite with minor chalcopyrite and pyrrhotite.

Disseminated to massive pyrite occurs as rusty zones in a 50–200 m wide transition zone between the massive rhyolites and sericite schist (Fig. 1). Pyrite mineralisation also occurs as fine-grained pyrite in centimetre to decimetre thick massive layers with quartz, and as large pyrite grains with highly strained rims in a quartzsericite matrix. In the northern part of the area the rusty pyrite-bearing zones are often sheared. This type of pyrite mineralisation is stratiform and occurs at several levels.

Disseminated pyrite in the carbonatised areas. Carbonatised rocks commonly have varying amounts of disseminated pyrite, up to 5% by volume. The pyrite is commonly recrystallised to euhedral crystals, but sometimes it exhibits cataclastic textures. Chalcopyrite is interstitial to pyrite grains and also occurs in cataclastic cracks and voids.

Table 1. Gold concentrations in different rock types of the eastern Eqi area

	N	range (ppb)	median (ppb)	No of samples with Au > 0.5 ppm
Rock samples				
acid rocks	62	5–1100	9	3
acid dykes	6	1–33	2	0
sulphide-rich rocks	8	5–172	16	0
basic rocks	11	1–126	11	0
carbonate-altered rocks	51	5–5850	22	6
quartz-veined rocks	26	5–60 000	69	8
Chip samples				
acid rocks	36	1–3000	5	3
carbonate-altered rocks	67	1–2350	5	2
quartz-veined rocks	43	1–1656	32	6

Acid rocks: rocks from the acid igneous complex as well as a variety of quartz-feldspar-sericite schists with occasional quartz and feldspar porphyroclasts. Most of these rocks have been altered by sericitisation and carbonatisation and formation of green mica. **Acid dykes**: samples belonging to the feeder dyke system associated with the acid igneous complex (Fig. 1). Pyrite occurs locally in very small amounts. **Sulphide-rich rocks**: rocks rich in fine grained primary pyrite in centimetre to decimetre thick layers or with euhedral remobilised disseminated and veinlet pyrite, which may be associated with chalcopyrite. **Basic rocks**: meta-pillow lavas altered to greenstones. Small amounts of pyrite occur disseminated within the greenstones. **Carbonate-altered rocks**: very carbonate-rich rocks with characteristic brown weathered surfaces. All samples contain varying proportions of pyrite. **Quartz veins**: quartz veins are common in carbonate-altered rocks, but also occur locally in all other rock types. Also included here are quartz-rich samples which mainly consist of vein material. Quartz veins contain variable amounts of pyrite.

Pyrite in quartz veins. Pyrite also occurs disseminated and as up to 20 mm euhedral crystals in quartz veins, locally with chalcopyrite. The quartz veins (up to several decimetres thick) are discordant to S_1 schistosity and lithological units, and occur in small shear zones in the carbonate-altered rocks and in adjacent altered acid metavolcanics indicating that the veins post-date the carbonate alteration. The strike of the shear zones is generally 140° with a dip of approximately 30° NE.

Pyrrhotite. Pyrrhotite makes up a minor proportion of the sulphides in the area, but can be found locally in abundance in breccia zones formed where discordant shear zones cut graphite-bearing layers.

Geochemistry

A total of 298 rock and chip samples from the eastern Eqi area were analysed for gold during the various investigations. Some of the samples were also analysed for 30 minor and trace elements by instrumental neutron activation analysis (INAA), and in addition all anomalous gold-bearing samples were re-analysed for Au by fire assay and atomic absorption spectropho-

tometry (AAS). Base metals were determined by AAS after digestion in aqua regia. Major elements were determined by X-ray fluorescence spectrometry (XRF) on glass discs. Analytical data for some of the elements are shown in Tables 1 and 2.

Two types of samples were analysed (Table 1): (1) samples of specific rock types and (2) chip samples each representing 2.5 m per sample (Fig. 5) often with mixed rock types. The latter were weighted with respect to the proportion of different rock types and classified as shown in Table 1.

General. The basic rocks are tholeiitic in composition with SiO_2 contents in the range 49–56%; ratios between K_2O and Na_2O are typical for unaltered tholeiites. Various discrimination plots of minor elements suggest that the basic lavas may have originated in an island-arc or back-arc basin setting.

The rhyolitic rocks have SiO_2 contents ranging from 72 to 87%, but K_2O and Na_2O levels fall well outside the normal igneous range, suggesting that their composition was strongly affected by alteration. Alteration increases down the sequence, with the least altered rocks in the fragmentary part of the rhyolitic dome complex and the most altered in the lower massive

not exposed

carbonate-altered rock

rhyolitic rock

quarz veins

ultramafic dyke

strike and dip

fold axis with dip

mineral lineation

Gold in chip samples

>1000 ppb
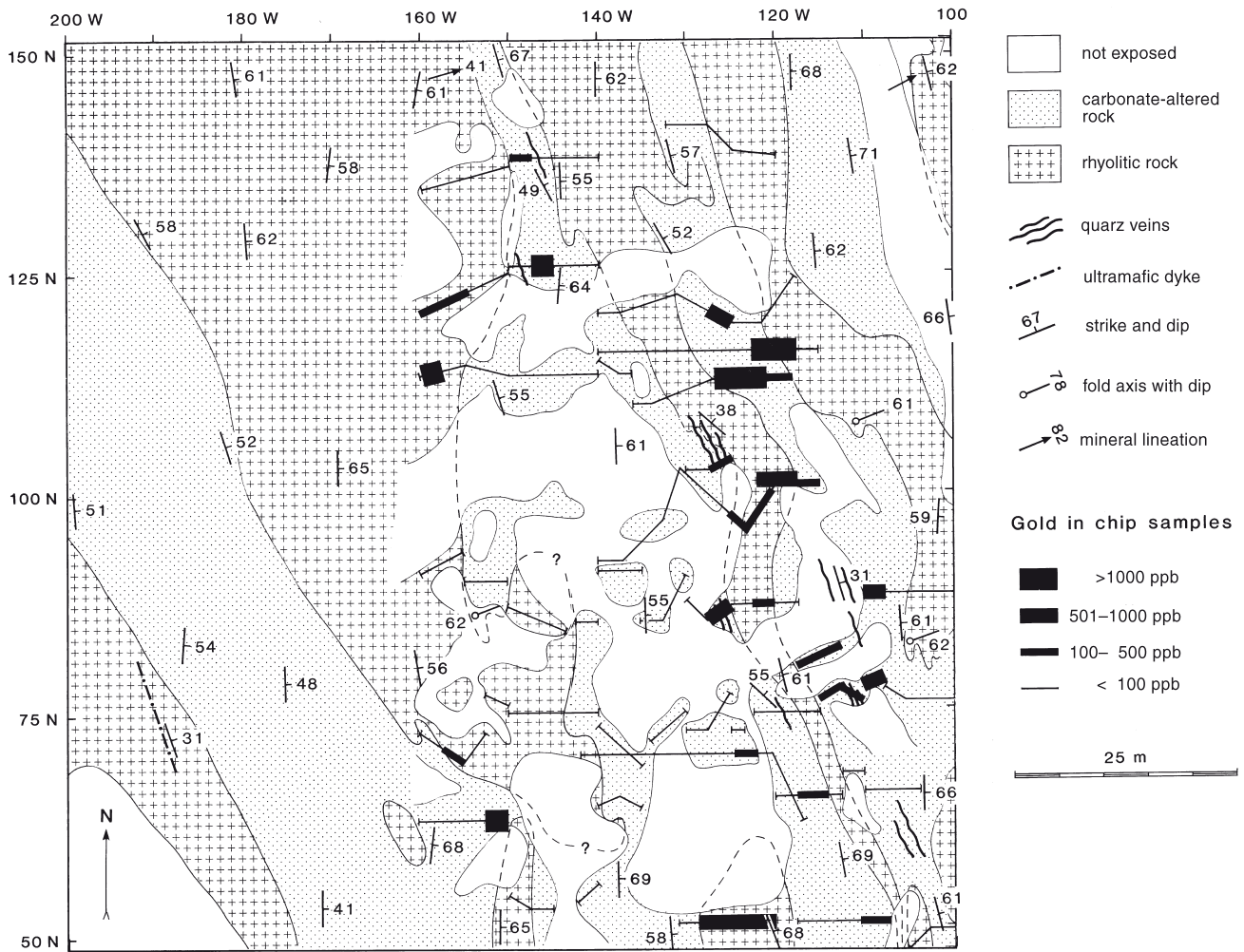
501–1000 ppb

100– 500 ppb

< 100 ppb

25 m

N

Fig. 5. 'Eqi East Prospect' with profile lines and their gold contents; for location see Fig. 2. Coordinates in metres west and north of an arbitrary point on the base line shown on Fig. 2.

part and in the feeder dyke system. SiO_2 levels increase downwards while Na_2O and K_2O levels decrease. It is suggested that this reflects circulation of fluids, generated during successive phases of intrusion, from which the upper volcanics were relatively protected and hence have their magmatic composition better preserved. Discrimination plots using Y, Nb and Rb suggest the acid igneous suite may have been emplaced in an island-arc setting.

Gold. Median gold contents of rock and chip samples are given in Table 1. Enhanced gold values occur in the sulphide-rich rocks (stratiform occurrences, 16 ppb), the carbonate-altered rocks (22 ppb) and the quartz-veined rocks (69 ppb). Median gold values for chip samples of quartz-veined rocks are also elevated (32 ppb). High Au (>0.5 ppm) is found in several rock types (Table 1). Gold in the quartz-vein-bearing rocks varies between 5 and 60 000 ppb. The highest concentration (60 ppm) is from a composite grab sample of a pyrite-bearing quartz vein in the carbonate-altered rocks.

Figure 5 shows the distribution of Au in profiles based on chip samples in the 60×100 m² 'Eqi East Prospect'. High Au values occur particularly in the east of this area where the average is 411 ppb in 27 chip samples collected over a surface area of 500 m².

Other elements. Trace element analysis has been carried out on 28 rock samples from the 'Eqi East Prospect', and selected results are given in Table 2. The acid rocks have enhanced contents of As (average 52 ppm) and Cu (320 ppm) compared to average acid volcanics (generally <5 ppm As and <40 ppm Cu, according to Wedepohl 1969–1978). This appears to

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Table 2. Range and mean concentrations for selected trace elements in rocks of the Eqi area

	acid rocks		acid dykes		basic rocks		carbonate-altered rocks	
N	8		4		4		12	
element (ppm)	mean	range	mean	range	mean	range	mean	range
As	52	4–130	6	1–16	38	1–120	32	1–59
Ba	385	100–910	203	140–160	123	100–160	269	100–610
Co	34	6–110	6	1–10	111	37–280	44	12–91
Cr	265	5–1500	6	5–10	39	39–330	218	31–400
Cu	320	7–2161	40	7–118	234	94–348	89	37–212
Ni	128	50–290	<50	<50	113	50–180	134	56–200
Pb	4	2–11	5	2–10	<5	<5	<5	<5
Rb	52	5–130	33	5–47	<5	<5	25	5–56
Zn	28	3–169	18	12–30	79	23–123	69	19–121

For rock types see text and footnotes to Table 1.

reflect their strong alteration. Chromium shows extreme variation, with values up to 1500 ppm (generally <20 ppm in acid igneous rocks). On the other hand, Rb values (52 ppm) are lower than in most acid igneous rocks (commonly >100 ppm). Ba values (385 ppm) are low in comparison with other acid igneous rocks (commonly >1000 ppm) but comparison is difficult because of a wide scatter of reported Ba values. Low Rb and Ba probably correspond to the decrease in K_2O and Na_2O observed in the altered rocks. The carbonate- altered rocks show the same features as the acid rocks.

A multivariate statistical analysis was carried out on the rock samples from the eastern Eqi area using the Multivariate Statistic Package programme (Kovach 1990). The rock samples were treated as one population (N = 63) and the profile samples as another population (N = 30). 'Correponding Sample Analysis' and 'Principal Component Analysis' show the following trends: there is a general association between Au, Cu, Ag (and Cr); if the highest Cu values are omitted from the analysis, Au and Cr give a characteristic association. A second cluster is observed for As-Ba-Rb. If gold values are omitted from the statistical analysis, the elements can be grouped as follows: (1) Cr, (2) Rb-Ba, and (3) As-Co-Cu. The chip sample profiles show a strong association between SiO_2 and Au. Associations such as Au-Cu-Ag and As-Rb-Ba are characteristic of hydrothermal mineralisation, and support the contention that the concentrations of Au, As, Cu, Cr, Ba and Rb are strongly influenced by alteration.

Discussion

Geological setting

The Eqi area shows many stratigraphic and lithological similarities with the Abitibi greenstone belt in Canada (Hodgson 1986), especially at the Dome Mine, Timmins area, Ontario (Fyon & Crocket 1983; Moritz & Crocket 1991). Notable parallels in geological setting are: (1) bimodal volcanism, (2) hydrothermal alteration and (3) the relationship between the gold mineralisation and carbonatisation, and late stage quartz veining.

Geochemistry

The eastern Eqi area is characterised by primary hydrothermal alteration with enrichment in SiO_2 and Al_2O_3 in the lower part, probably caused by leaching of and deposition of Ca and other elements in the carbonate-altered zone. Element associations obtained by the multivariate statistical analysis indicate remobilisation of Au, Ag, As, Cu, and Cr during hydrothermal alteration processes. The association between Au and SiO_2 probably reflects the relation between high gold values and quartz veins. Mobilisation of hydrothermal fluids was probably related to the acid magmatic activity.

A close association of Au-Cu-Ag has also been reported from the 'Eqi West Prospect' (Sotka 1984). This mineralisation, which occurs in brittle deformed rocks, is clearly epigenetic, and could represent metals remobilised from an eastern Eqi type primary mineralisation.

Gold contents in the rocks of the 'Eqi East Prospect' are comparable to other areas with Au-bearing Archaean volcanic rocks. Rhyolitic rocks and acidic dykes at Eqi contain 9 ppb and 2 ppb Au, respectively (Table 1). Granitic plutons normally contain 1–2 ppb Au (Crocket 1991), but Boyle (1991) reports up to 50 ppb Au for quartz-feldspar porphyries in Archaean greenstone belts. The basic rocks at Eqi yield on average 11 ppb Au (Table 1) compared to 5.7 ppb Au for Precambrian tholeiitic basalts (Crocket 1991) and 3 ppb for average basalt (Boyle 1991). Anomalous Archaean greenstone belts are known from Southern Africa (Saager et al. 1982) and from Bogoin, Central African Republic (komatiitic and tholeiitic basalts, Dostal et al. 1985), which yield averages of 10.8 and 37.1 ppb Au respectively.

Alteration and formation of gold mineralisation

Hydrothermal alteration occurred initially in the form of leaching and carbonatisation of the volcanic sequence, which was most intense in and just above the feeder dyke system. It was followed by sericitisation, formation of green mica and chloritisation. This evolution of the alteration is similar to that observed in many deposits in the Timmins area, Ontario, e.g. at the Dome Mine (Fyon & Crocket 1983, Moritz & Crocket 1991).

Formation of the primary gold mineralisation at eastern Eqi is related to the pervasive carbonate alteration. Remobilisation of gold into late (post-S_1) quartz veins occurred at the 'Eqi East Prospect'. These quartz veins host the highest gold concentrations. A prominent feature seen in eastern Eqi as well as in western Eqi is that the gold-bearing sulphides often are located where post-S_1 veins or shear zones cut graphite-rich layers. This suggests that deposition or remobilisation of gold may here be controlled by strongly reducing conditions.

Eqi and Abitibi, Canada: parallels and contrasts

Hodgson et al. (1982) have suggested exploration criteria for gold mineralisation in greenstone belts based on Archaean gold mines in Canada. In the following some of these criteria are discussed with parallels and contrasts between gold mines in the Timmins area, Abitibi belt, and the 'Eqi East Prospect'.

1. Hodgson et al. (1982) noticed a very common association of gold with acidic rocks. Although the proportion of acid volcanic rocks is much smaller than that of mafic rocks, over 90% of the gold deposits are connected to intrusive or extrusive acid rocks. This is also the case at Eqi. A contrast is the large apparent stratigraphic thickness of volcanic rocks in the Abitibi greenstone belt (c. 40 km; Hodgson 1986) compared to one tenth of this thickness at Eqi.

2. Hodgson et al. (1982) divided the gold deposits into four main types depending on their relationships to the felsic host rock. The primary enrichment at the 'Eqi East Prospect' is comparable to the so-called 'Dome-type' which is a vein or stratiform ore zone hosted mainly by volcanic rocks with associated quartz-bearing felsic rocks.

3. Iron-rich sedimentary rocks are commonly associated with the Dome-type deposits. In the Abitibi belt occurrences magnetite exhalites are closely associated with the ore. In the eastern Eqi area these horizons (graphite-bearing phyllites with iron oxides) occur stratigraphically above the hydrothermally altered and gold mineralised area in the volcanic stratigraphy (Fig. 2). At the 'Eqi West Prospect' iron formation lies close to epigentic Cu-Au mineralisation.

4. Major carbonate alteration is common in eastern Eqi. In the Canadian gold deposits carbonate alteration is ubiquitous (e.g. in the Rundle gold deposit; Love & Roberts 1991).

5. A major change in lithology occurs in some of the Canadian deposits. In eastern Eqi the gold mineralisation is closely associated with the boundary between basic and acid igneous rocks and associated spatially with acid intrusive rocks. In western Eqi the Cu-Au mineralisation is closely associated with a thrust zone.

6. In the Canadian Shield gold is often associated with arsenopyrite, scheelite and tourmaline. This is especially characteristic for the intrusive-hosted deposits. In addition, pyrite is common, while green mica ('fuchsite') occurs only in some of the deposits. Eastern Eqi samples show enhanced As values, but As concentrations are not very high. Tourmaline is widespread at eastern Eqi and a small piece

of scheelite has been discovered under ultra-violet light in addition to an enhanced level of tungsten in heavy mineral concentrates (51–95 ppm W) compared to the regional background pattern.

7. Many of the Canadian gold mines in greenstone belts have a predominance of pyrrhotite over pyrite (Colvine 1989) whereas at eastern Eqi the rock is dominated by pyrite.

Conclusions

The gold mineralisation at the 'Eqi East Prospect' is hosted by a c. 2800 Ma old basic–acid succession that may have been formed in an island-arc environment. Mineralisation took place in two phases: (1) a primary, pervasive mineralisation caused by hydrothermal leaching and carbonate alteration of the rock pile related to acid igneous activity, and (2) during the formation of late quartz veins when gold was remobilised and deposited together with iron sulphides.

The 'Eqi East Prospect' has many similarities to gold mines in the Abitibi greenstone belt, especially the Timmins area, with respect to geological setting, geochemistry and mode of emplacement.

In the western Eqi area gold mineralisation is located in sulphide-bearing breccia zones close to the thrust zone which separates the eastern and western supracrustal successions.

Acknowledgement

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