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Primary characters and polymetamorphic evolution of the Precambrian basement in the Angmagssalik district (SE Greenland)

RICCARDO TRIBUZIO, BRUNO MESSIGA
Dipartimento di Scienze della Terra, Università di Pavia, Via A. Bassi 4, 27100 Pavia

GIOVANNI B. PICCARDO
Dipartimento di Scienze della Terra, Università di Genova, Corso Europa 26, 16132 Genova

RICCARDO VANNUCCI
Dipartimento di Scienze della Terra, Università di Pavia e CNR - Centro di Studio per la Cristallografia Strutturale, Via A. Bassi 4, 27100 Pavia

The Nagssugtoqidian Mobile Belt (NAG) in East Greenland (Fig. 1) is mainly composed of Archaean rocks affected to a variable extent by two main deformational events, respectively 2600 and 1900 Ma old (BRIDGWATER & MYERS, 1979). In the Angmagssalik District the basement consists of prevalent ortho-and paragneisses, ultramafic and mafic (mainly amphibolite) rocks, intruded by Proterozoic mafic dykes and syn- / post-orogenic plutons.

The major-element chemistry of the orthogneisses indicates granodioritic composition and calcalkaline affinity, whilst the amphibolites show a transitional basaltic composition (Fig. 2). HYGE distributions of orthogneisses (Fig. 3) follow the patterns of normal continental-arc granitoids (BROWN et al., 1984), suggesting an origin at the destructive plate margin. HYGE patterns of amphibolites are largely LILE-enriched and may be related either to ocean-floor tholeiites from a metasomatised mantle or to island-arc basalts (Fig. 3).

However some of the observed LILE abundances may be ascribed to dehydration / hydration processes occurring during granulite - amphibolite metamorphism, as suggested for the Lewisian grey gneisses of N-W Scotland by FOWLER (1986). K and Rb depend on the occurrence of biotite, K-feldspar and amphibole, Th is stabilised in

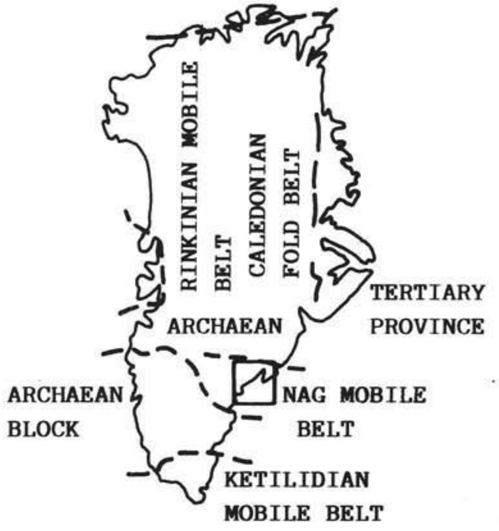

Fig. 1. — Index map showing main structural outlines of Greenland. Open square: Angmagssalik District.

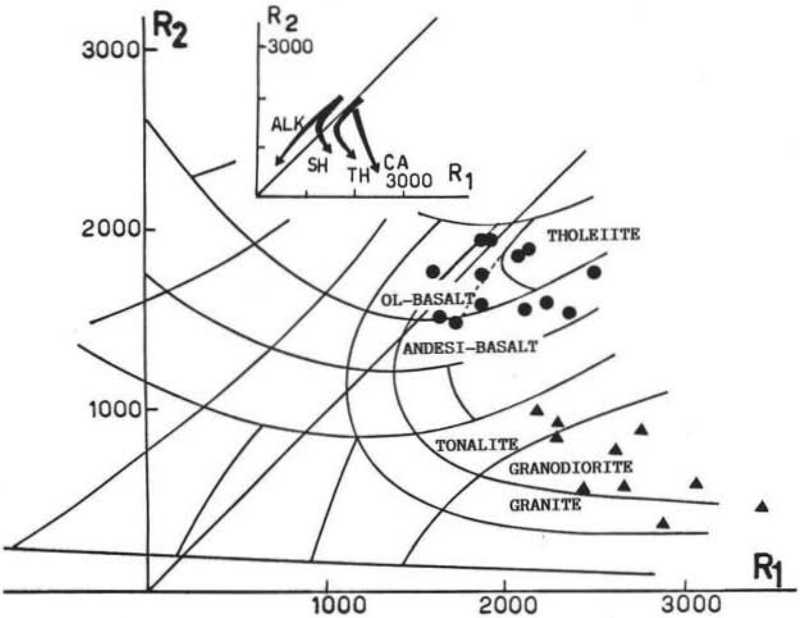

Fig. 2. — R1-R2 diagram (DE LA ROCHE et al., 1980) for mafic amphibolites (circles) and orthogneisses (triangles) from Angmagssalik Basement.

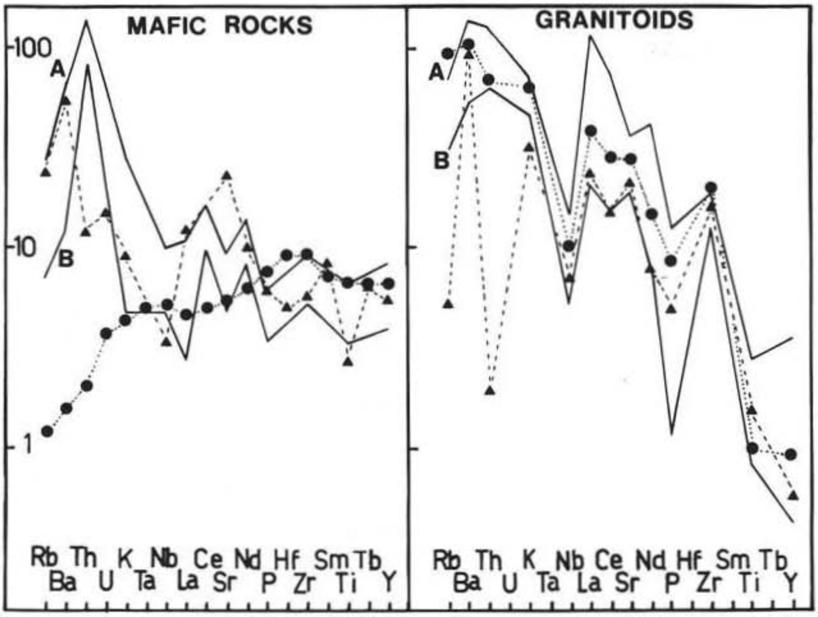

Fig. 3. — HYGE distribution in metavolcanic amphibolites and orthogneisses from Angmagssalik Basement. MAFIC ROCKS: A-B = compositional field of amphibolites. HYGE distribution patterns of N - MOR basalts (solid circles) and Island - Arc basalts (solid triangles) are reported for comparison. GRANITOIDS: A-B = compositional field of orthogneisses. HYGE distribution patterns of Lewisian grey gneisses, with SiO_2 content > 60% are also reported: amphibolite facies (solid circles); granulite facies (solid triangles). Data after WEAWER & TURNEY (1980, 1981).

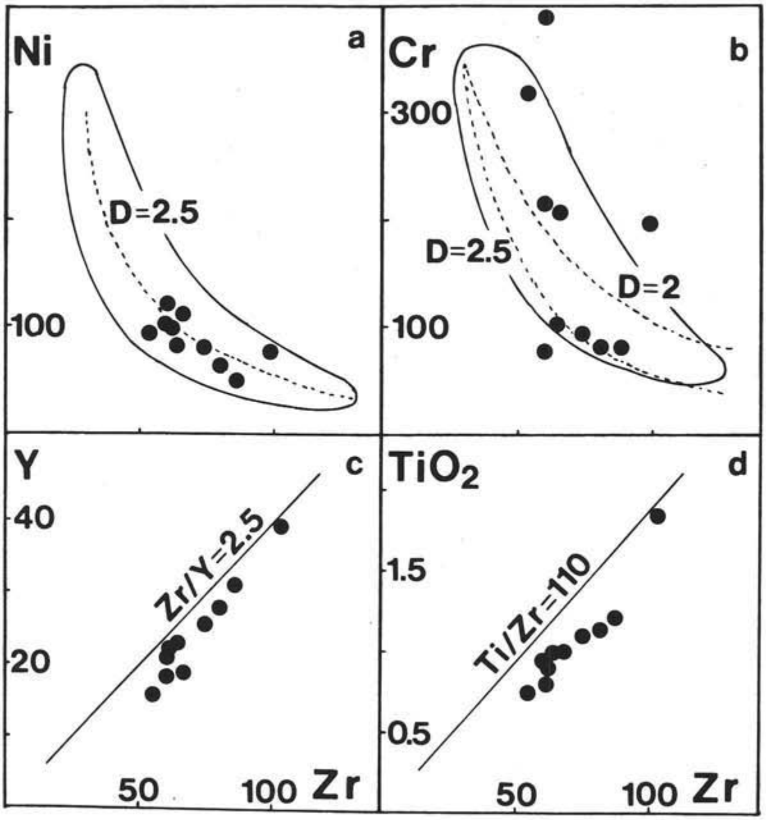

Fig. 4. — Ni, Cr, Y, TiO_2 vs. Zr diagrams for metavolcanic amphibolites from Angmagssalik Basement. (a) and (b): compositional fields of Archaean amphibolites from Fiskenaesset (S-W Greenland); calculated fractionation trends (dashed lines) and bulk distribution coefficients, by fractionating an 0l (15%) - Opx (20%) - Cpx (15%) - Pl (50%) assemblage from a parental liquid with Zr 30 ppm, Ni 30 ppm, Cr 35 ppm (after WEAVER et al., 1982), (c) and (d): Zr/Y and Ti/Zr chondritic ratios (SUN, 1980).

allanite, apatite and zircon.

These considerations allow us to assign an ocean floor, as opposed to island - arc affinity, to the mafic amphibolites. The same tectonic environment has been postulated on geochemical grounds by WEAVER et al., (1982) for the meta-volcanic amphibolites from Fiskenaesset (Archaean block, SW Greenland, ca. 2800 Ma).

Most of HFSE in amphibolites show no evidence of remobilization as suggested by the good linear covariations (Fig. 4), which are assumed to reflect primary igneous processes.

Between the possible petrogenetic models crystal fractionation better matches the observed Cr, Ni vs. Zr distributions. The proposed model (Fig. 4), suggesting a prevalent role of the plagioclase ($> = 50\%$) in the fractionating assemblage, is indicative of low-pressure crystal fractionation processes.

On the basis of geochemical data the amphibolites seem to represent fragments of Archaean oceanic crust emplaced into the deep crustal levels during crustal accretion.

The meso- and microtextural aspects of the metamorphic evolution of these rocks can be investigated in details since the late metamorphic event, in amphibolite facies conditions, still preserves relics of older parageneses. Therefore the metamorphic history have been reconstructed on eclogite relics-bearing amphibolites which, in turn, preserve widespread microtextural and paragenetic relics of the older metamorphic

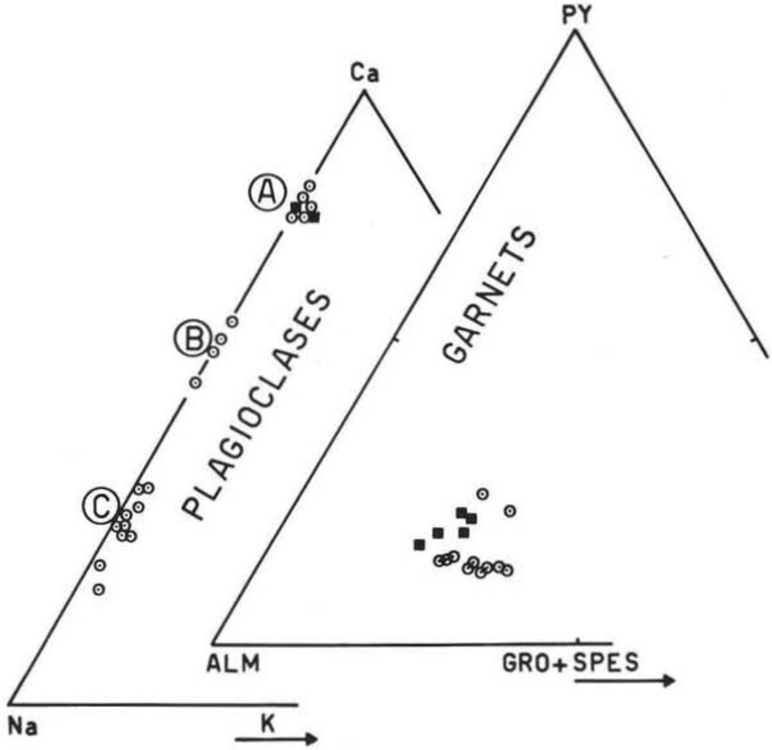

Fig. 5. — Compositional variations of garnets and plagioclases in amphibolites (open circles) and paragneisses (full squares). Plagioclases refer to: plagioclases on pseudomorphoses after Na-clinopyroxenes (C) and garnets (A) in eclogite - bearing amphibolites; plagioclases recrystallised with hornblendes in pl-amphibolites (B).

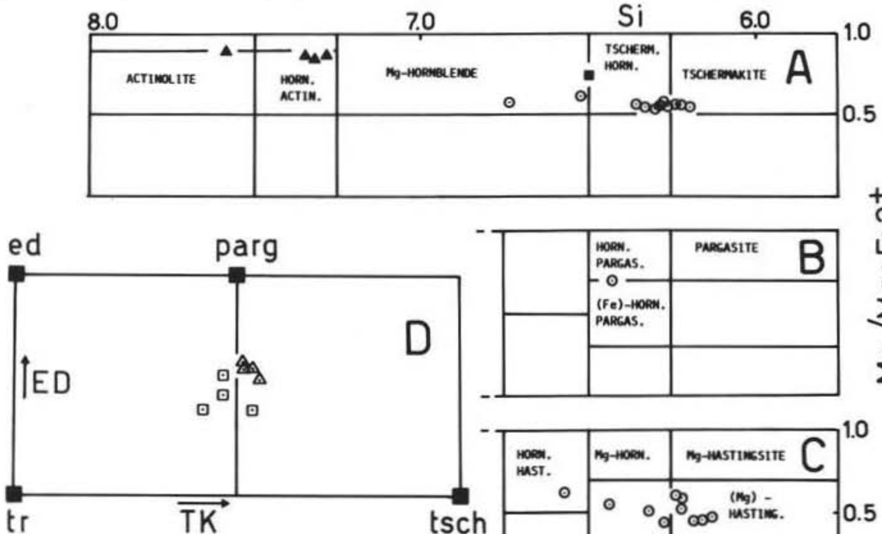

Fig. 6 - Chemical variations of amphiboles from ultramafites (3), paragneisses (4), amphibolites (5) on LEAKE'S (1978) classification diagram (A, B and C). D): hornblende compositional variation in terms of additive component (Tr) and exchange vector (ED and TK). 1) hornblendes recrystallised with plagioclase in amphibolites; 2) coronitic hornblendes from eclogite-bearing amphibolites.

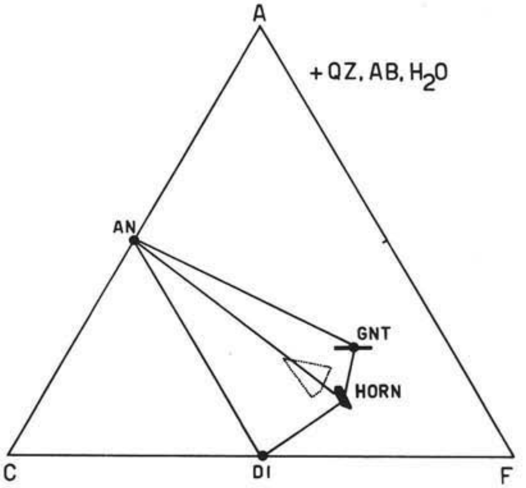

Fig. 7. — ACF projection pertinent mineral compatibility of amphibolites. Dotted enclosure: field of bulk rock chemistry.

association. The eclogitic assemblage can be reconstructed and was characterised by garnet and Na-clinopyroxene association.

The garnets exhibit an overgrowth of kelyphitic rims of ortopyroxene + An-plagioclase + ores; the microtextural relics of Na-clinopyroxenes are constituted by symplectites of diopsidic clinopyroxene and Ab-plagioclase.

A subsequent rim of plagioclase and green hornblende appears as corona between symplectites and relic garnets.

The pervasive reequilibration in amphibolite facies conditions gives assemblages characterised by the hornblende + plagioclase stability.

In summary the mafic rocks show four different superimposed parageneses (1):

1) **Mineral abbreviations**: Ab = albite; Alm = almandine; Amph = amphibole; An = anorthite; And = andalusite; Cpx = clinopyroxene; Ed = edenite; Gnt = garnet; Gro = grossular; Horn = hornblende; Jd = jadeite; Ky = kyanite; Na-cpx = sodic clinopyroxene; Ol = olivine; Opx = orthopyroxene; Or = ores; Parg = pargasite; Pl = plagioclase; Py = pyrope; Qz = quartz; Sil = sillimanite; Spes = spessartine; Tr = tremolite; Tsch = tschermakite; ED = $NaAlSi_{-1}$; TK = $Al_2Mg_{-1}Si_{-1}$.

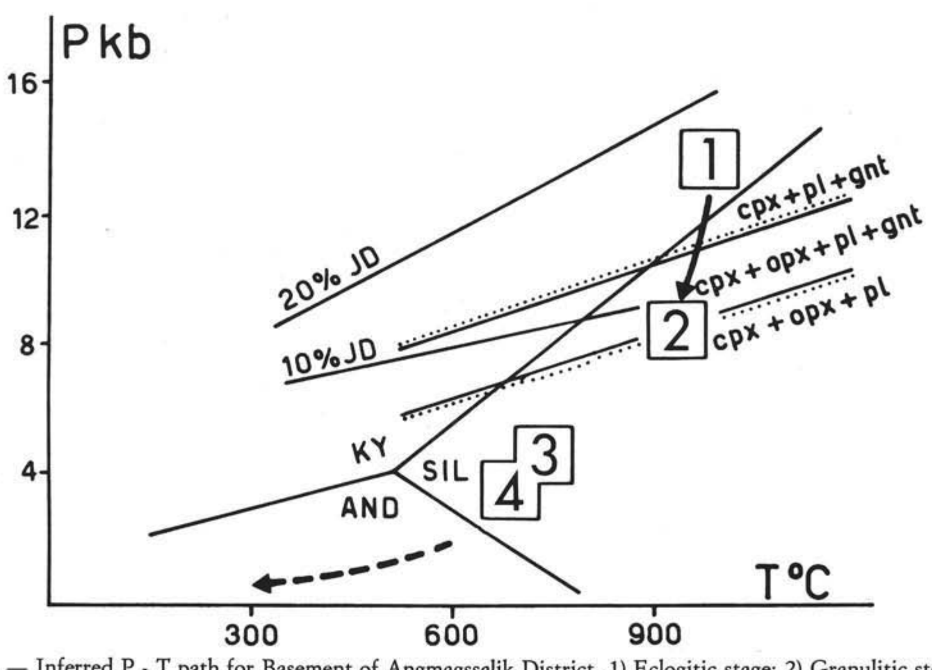

Fig. 8. — Inferred P - T path for Basement of Angmagssalik District. 1) Eclogitic stage; 2) Granulitic stage; 3) Amphibolite coronitic stage; 4) Amphibolite stage. Curves for Jd content in clinopyroxenes from HOLLAND (1983). Al-silicate triple point from HOLDAWAY (1971). Curves for granulite - eclogite transition from GREEN & RINGWOOD (1967).

1) Na-cpx + gnt ± qz (inferred);
2) pl + cpx + opx + or ± gnt;
3) horn + pl (crystallised as coronitic rim between gnt and cpx);
4) pl + horn ± gnt ± cpx ± bt.

Mineral assemblage varies according to the following metamorphic reactions.

Metamorphic reactions

1) Na-cpx + Qz----Cpx + Ab + An
2) Gnt----An + Opx + Or + Qz
3) Qz + Gnt + Cpx + H_2O----An + Horn
4) 1.0 Amph (2)----1.0 Amph (1) + 0.2 ED + O.3 TK (2 = coronitic amphibole; 1 = granoblastic amphibole).

Plagioclase composition A and C (Fig. 5) refer to pseudomorphic plagioclase after garnet and Na-clinopyroxene respectively (reactions 1 and 2). Plagioclase composition B represents recrystallised grains in granoblastic aggregates with hornblende in the amphibolites. Garnet from mafic rocks as well as from paragneisses shows low pyrope content and their composition is scattered according to bulk composition of the host rock. Hornblendes in mafic rocks range in composition from hastingsites to tschermakites (Fig. 6/a, b, c). Hornblendes in granoblastic aggregates show increasing of TK and ED substitutions, in comparison with hornblendes in coronas around garnets (Fig. 6 - reaction 4).

Chemographic relationships on the ACF projection indicate that three different parageneses may characterize the amphibolite facies in mafic rocks (Fig. 7): 1) horn + gnt + pl; 2) horn + pl; 3) horn + pl + cpx.

The different assemblages in the mafic rock-types allow the following evolution to be reconstructed:

1) an hypothetical early event under eclogitic conditions;
2) a subsequent partial reequilibration under granulite facies conditions;
3) a third event with incipient amphibolitisation displaying coronitic textures;
4) a final event which can produce pervasive transformation under amphibolite facies conditions, if associated with kinetic constraints as fluid activity and/or deformations.

P - T estimates for the evolutionary steps have been determined according to recent experimental data on the pertinent systems (Fig. 8). Summing up petrological and geochronological data, steps 3 and 4 may be ascribed to a retrograde evolution of high grade metamorphic rocks (steps 1 and 2), and they are connected to the later tectonometamorphic event (1900 Ma).

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