Australian Journal of Earth Sciences (1989) **36**, 219–241

Geology and structure of the Larsemann Hills area, Prydz Bay, East Antarctica

Kurt Stüwe,[1] Hans-Martin Braun[2] and Helmuth Peer[3]

[1]*Department of Geology, University of Melbourne, Parkville, Vic. 3052, Australia.*
[2]*Geologisch-Paläontologisches Institut der Universität, 6000 Frankfurt, West Germany.*
[3]*Forschungsgesellschaft Joanneum, Sektion Rohstofforschung, Roseggerstrasse 15,8700 Leoben, Austria.*

The Larsemann Hills area in Prydz Bay, East Antarctica, underwent low pressure granulite facies metamorphism about 1100 Ma ago. This peak metamorphic age is similar to that of large areas west of the Larsemann Hills, but contrasts with the Archaean age of the Vestfold Hills only 100 km to the northeast. The dominant rock types in the Larsemann Hills are metapelitic cordierite- and Fe–Ti oxide-rich gneisses and various leucogneisses. Felsic, garnet-bearing, variably foliated 'yellow gneiss' (60% of outcrop) and the extremely cordierite-rich 'blue gneiss' (10% of outcrop) constitute the two major metasedimentary units. Mafic dykes, charnockites and evidence of brittle deformation are absent, and there are minor orthogneisses as well as mafic two pyroxene gneisses that lack garnet and ultramafic rocks. These features distinguish the Larsemann Hills not only from the Archaean Vestfold Hills to the northeast, but also from the 1000 Ma old 'transition zone' in the Rauer Group and outcrops of similar age to the southwest.

Three major deformation phases affected the Larsemann Hills area. The first deformation, D_1, took place prior to and synchronously with the peak metamorphic event M_1 and formed tight, isoclinal folds which cannot be resolved on a regional scale. The second deformation, D_2, the major outcrop-scale shortening deformation, took place at the time of decompression (M_2) from the metamorphic peak, and subsequent minor deformation may have continued during cooling to the stable geotherm. The third deformation, D_3, folded the Larsemann Hills gneisses into a large, knee-shaped fold plunging steeply to the southwest. Overprinting of many textures by large porphyroblasts and granitic melts indicates that a thermal event (M_3) or rapid increase in H_2O activity affected the area after the pervasive ductile deformations. This event may correlate with D_3 and may have been responsible for the excavation of the Larsemann Hills during the Palaeozoic.

Key words: Antarctica, decompression, Proterozoic granulites, Prydz Bay.

INTRODUCTION

The Larsemann Hills are a series of icefree peninsulas and islands along the coast of the East Antarctic Shield, about 100 km southwest of the Vestfold Hills (Fig. 1). Unlike the Vestfold Hills and many other icefree exposures of the East Antarctic Shield, Phanerozoic cover sequences and Cainozoic moraine deposits are almost absent from the Larsemann Hills. These outcrops are the easternmost major outcrop area of an extensive terrain that was metamorphosed to granulite facies during the mid-Proterozoic (1000–1100 Ma) (Tingey 1982; Grew 1982; Sheraton *et al* 1984). This event is henceforth termed the 1100 Ma event. The next major outcrop area to the east, the Rauer Group, has been interpreted as the transition zone between this mid-Proterozoic terrain to the west and the adjacent Archaean Vestfold Hills block (Harley 1987). The 1100 Ma Proterozoic belt appears to be flanked by three Archaean complexes (Fig. 1): the Vestfold Hills (Collerson & Arriens 1979; Oliver *et al* 1982), the southern Prince Charles Mountains (Tingey 1982) and the Napier complex of Enderby Land (Grikurov *et al* 1976; Sheraton *et al* 1980, 1987). K–Ar ages published for rocks from the Prydz Bay area are between 405 and 540 Ma (Piciotto & Coppez 1963; Ravich *et al* 1965), corresponding with the widely recognized 'Pan African event' in the East Antarctic Shield. It will be referred to henceforth as the 500 Ma event. Undeformed porphyritic granites of this age form major outcrops near Landing Bluff and at the Meknattane Nunataks 140 km southwest of the Larsemann Hills (Arriens 1975; Sheraton & Black 1988). Minor outcrops of undeformed granites within

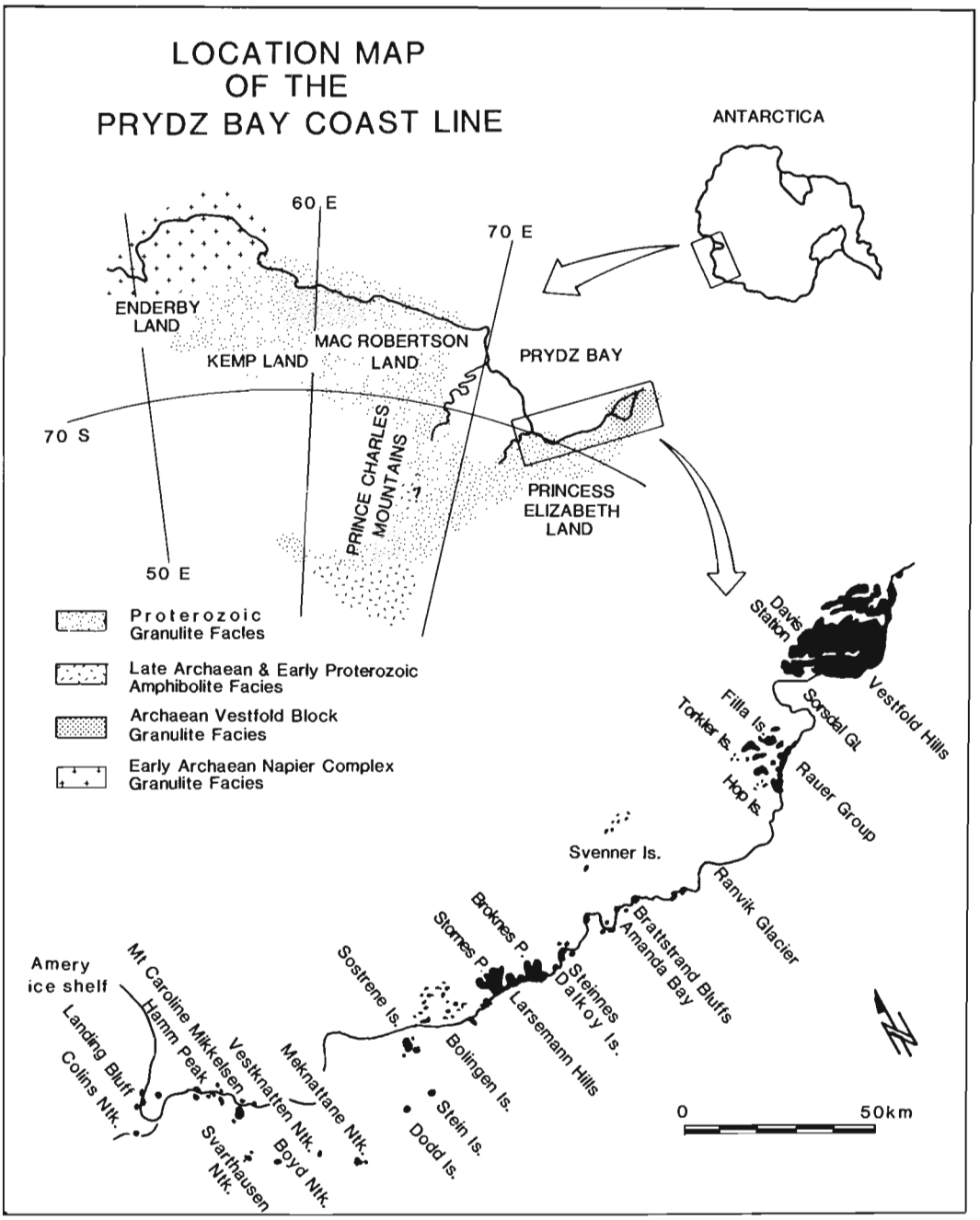


Fig. 1 Location and regional geological setting of the Larsemann Hills.

the Larsemann Hills area are presumed to be of similar age.

GEOGRAPHY

The name Larsemann Hills applies to two major and four minor peninsulas, as well as 10 major and about 120 minor islands between 69°20′S, 76°00′E and 69°30′S, 76°30′E in Prydz Bay. The total icefree area covers about 40 km^2 and the highest elevations are around 180 m asl. The area constitutes more than 90% of the total outcrop between the Rauer Group and the Amery Ice Shelf and is the focus of this discussion. Because base maps of reasonable scale for geological mapping did not previously exist for the Larsemann Hills, much of the geological field work was preceded by topographic sketch mapping at 1:25 000 scale (Fig. 2). Previous topographic work is limited (Soviet 1: 100 000 map; National Mapping aerial photography 1967 black & white; 1980 colour; Landsat imagery February 1973: path 131, row 109, no. 1196/02512). Gridding of the map was done with SATNAV fix positions from the Nella Dan and the MV Icebird and with calculated JMR fix positions. Absolute elevations were measured barometrically.

ROCK TYPES

The rocks in the Larsemann Hills are dominantly low pressure granulite facies metasedimentary gneisses, and partial melt bodies. They are characterized by, and distinguished from, other basement outcrops in East Antarctica by: (1) the absence of mafic dykes, metamorphosed or unaltered; (2) rare calc-silicate rocks; (3) minor mafic, pyroxene-bearing gneisses; (4) the absence of charnockites; (5) the absence of shear zones, ultramylonites and pseudotachylites; (6) signs of brittle deformation being restricted to small faults with displacement of no more than 1 m, despite the existence of several sets of lineaments on aerial photographs.

The above features are restricted to the Larsemann Hills and possibly partly to the Bolingen Islands from which shear zones have been recorded (S. Harley pers. comm. 1988). The different rock types recognized in the Larsemann Hills are described in order of abundance (Fig. 3). Details of the mineralogies in relation to the metamorphic events and deformation phases are summarized in Table 1.

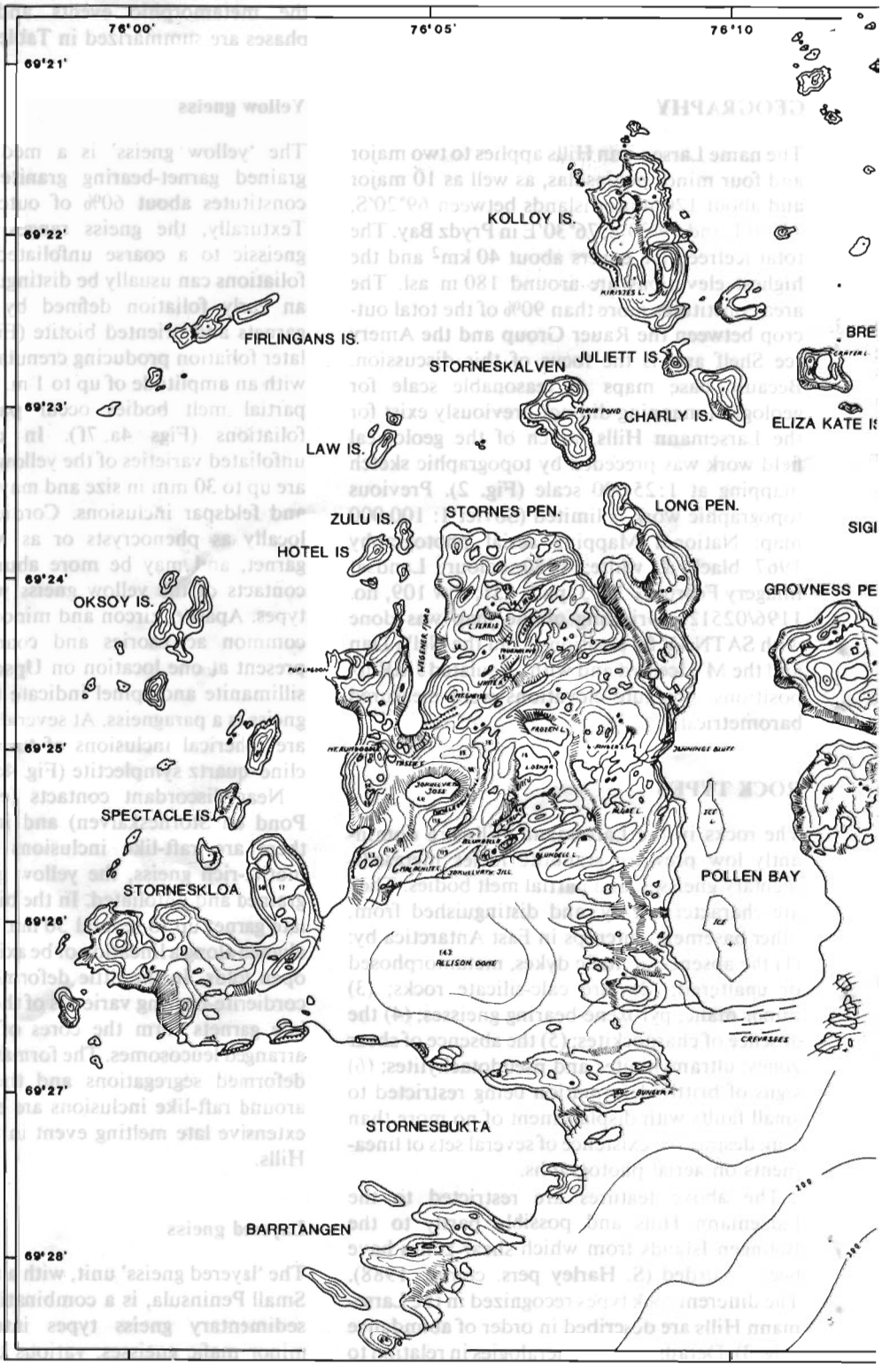
Yellow gneiss

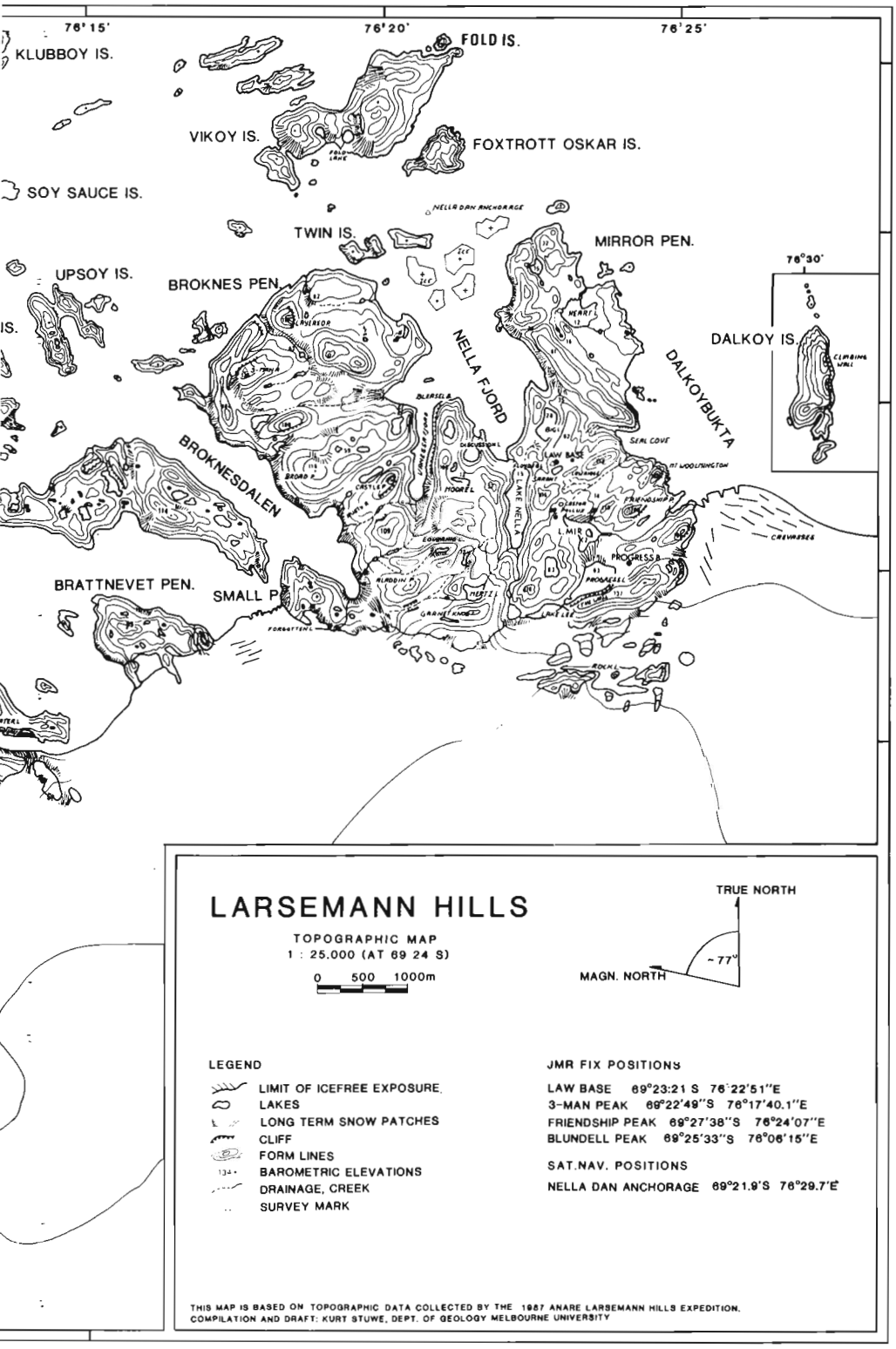
The 'yellow gneiss' is a medium to coarse grained garnet-bearing granite gneiss which constitutes about 60% of outcrop (Table 1). Texturally, the gneiss ranges from strongly gneissic to a coarse unfoliated granite. Two foliations can usually be distinguished. There is an early foliation defined by small aligned garnets and oriented biotite (Fig. 4b,d) and a later foliation producing crenulations and folds with an amplitude of up to 1 m. Coarse grained partial melt bodies occur parallel to both foliations (Figs 4a, 7f). In coarse grained unfoliated varieties of the yellow gneiss, garnets are up to 30 mm in size and may contain quartz and feldspar inclusions. Cordierite is present locally as phenocrysts or as M_2 coronas on garnet, and may be more abundant near the contacts of the yellow gneiss with other rock types. Apatite, zircon and minor magnetite are common accessories and coarse graphite is present at one location on Upsoy Island. Rare sillimanite and spinel indicate that the yellow gneiss is a paragneiss. At several locations there are spherical inclusions of tourmaline–microcline–quartz symplectite (Fig. 4c).

Near discordant contacts (e.g. near Anna Pond on Storneskalven) and in places where there are raft-like inclusions of a foliated, biotite-rich gneiss, the yellow gneiss is coarse grained and unfoliated. In the biotite-rich rafts, late garnet up to several 30 mm in size may be aligned along a lineation or be axial planar to late open folds. In the little deformed biotite- and cordierite-bearing varieties of the yellow gneiss, late garnets form the cores of concentrically arranged leucosomes. The formation of such undeformed segregations and the coarse melts around raft-like inclusions are evidence for an extensive late melting event in the Larsemann Hills.

Layered gneiss

The 'layered gneiss' unit, with a type locality on Small Peninsula, is a combination of all metasedimentary gneiss types interlayered with minor mafic gneisses, various types of partial


76°00'
76°05'
76°10
69°21'
69°22'
69°23'
69°24'
69°25'
69°26'
69°27'
69°28'
KOLLOY IS.
FIRLINGANS IS.
STORNESKALVEN
JULIETT IS.
CHARLY IS.
ELIZA KATE IS
LAW IS.
ZULU IS.
HOTEL IS
STORNES PEN.
LONG PEN.
OKSOY IS.
GROVNESS PE
SPECTACLE IS.
STORNESKLOA
POLLEN BAY
STORNESBUKTA
BARRTANGEN


76°15'
76°20'
76°25'
76°30'
KLUBBOY IS.
FOLD IS.
VIKOY IS.
FOXTROTT OSKAR IS.
SOY SAUCE IS.
NELLA DAN ANCHORAGE
TWIN IS.
MIRROR PEN.
UPSOY IS.
BROKNES PEN.
DALKOY IS.
CLIMBING WALL
NELLA FJORD
DALKOYBUKTA
SEAL COVE
BROKNESDALEN
LAKE NELLA
BRATTNEVET PEN.
SMALL P
CREVASSES
LARSEMANN HILLS
TOPOGRAPHIC MAP
1 : 25.000 (AT 69 24 S)
0 500 1000m
TRUE NORTH
~77°
MAGN. NORTH
LEGEND
LIMIT OF ICEFREE EXPOSURE
LAKES
LONG TERM SNOW PATCHES
CLIFF
FORM LINES
BAROMETRIC ELEVATIONS
DRAINAGE, CREEK
SURVEY MARK
JMR FIX POSITIONS
LAW BASE 69°23:21 S 76°22'51"E
3-MAN PEAK 69°22'49"S 76°17'40.1"E
FRIENDSHIP PEAK 69°27'38"S 76°24'07"E
BLUNDELL PEAK 69°25'33"S 76°06'15"E
SAT.NAV. POSITIONS
NELLA DAN ANCHORAGE 69°21.9'S 76°29.7'E
THIS MAP IS BASED ON TOPOGRAPHIC DATA COLLECTED BY THE 1967 ANARE LARSEMANN HILLS EXPEDITION.
COMPILATION AND DRAFT: KURT STUWE, DEPT. OF GEOLOGY MELBOURNE UNIVERSITY