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Tittel
The Geology of the Area Sundet, Sør-Trøndelag

Forfatter	Dato	År	Bedrift (Oppdragsgiver og/eller oppdragstaker)
Carter, Paul		1966	Orkla Grube A/B

Kommune	Fylke	Bergdistrikt	1: 50 000 kartblad	1: 250 000 kartblad
	Sør-Trøndelag			Trondheim

Fagområde	Dokument type	Forekomster (forekomst, gruvefelt, undersøkelsesfelt)
Geologi		Løkkenfeltet

Råstoffgruppe	Råstofftype
Malm/metall	Cu,Zn

Sammendrag, innholdsfortegnelse eller innholdsbeskrivelse

Kartlegging av nedre Ordovicium ved gården Sundet.
Fører sedimentære, vulkanske og intrusive bergarter. Strukturer i tidligere kartlagte områder er utvidet.
Strukturene i området er bestemt av to hovedfolderetninger. metamorfiseringen ligger i kloritt-biotitt.
Arbeidet er anagelig 1966, i alle fall etter 1963.

Vedlagt kart utsnitt og notat.

THE GEOLOGY OF THE AREA AROUND SUNDET, SØR-TRONDELAG

Abstract

An area of Lower Ordovician sedimentary, volcanic and intrusive rocks around the farm Sundet in Sør Trondelag has been mapped and this work makes it possible to extend the successions and structures previously recognised in neighbouring areas by Vogt (1945), Carstens (1952) and Chadwick and Co. (1963?). The "Jaren Beds" of Vogt are shown to be Houin Group. The structure of the area is determined by two major fold directions. The degree of metamorphism is chlorite-biotite.

Introduction

Excellent work on the Støren (Bymark of Carstens) and Houin Groups in the Lower Palaeozoic has been done in the low grade metamorphosed area south of Trondheim between Gaudålen and Orkladalen by Carstens, W., (& Carstens, H.) Th. Vogt, and Chadwick and Co. The present study which was carried out in order to correlate these three mapped areas, consisted of an investigation of an area of some 25 sq. miles (70 sq. kms.) around Sundet. An extension of this work into the neighboring areas mapped was carried out in order to make this correlation.

The mapping done by the present author was not as detailed as that of Chadwick and Co., but over 700 outcrops were examined in a period of 6 weeks in the dry summer of

1963. The exposure was not good, with valley alluvium, forest, and hill bog covering much of the geology, and few lithological or structural contacts were seen. This put the mapping ~~xxxxxxxxxxxxxxxxx~~ of intricate minor structures out of the question, but the mapping of large structures was still possible, and as the trends and lithologies were reasonably constant the present author considers his general conclusions to be justified.

The area was mapped on kodatrace overlays on aerial photographs kindly supplied by Orkla Grube Akliebolag. A mosaic was constructed from these to show roads, rivers and lakes at a scale of approximately 1:15,000. This mosaic has inaccuracies due to photographic aberration at the edges of the photographs, and human error, but is accurate anough for the work in hand.

Regional Correlation

For the purposes of regional correlation, previous work neighbouring the area ~~xx~~ mapped must be summarised.

Vogt (45) mapped a part of the Hølonda-Horg district as a basis for the stratigraphy of wider areas, and proposed the following succession (Table I) for the North West of the Hølonda-Horg area. This adjoins the east of the area around Sundet.

TABLE I

Clandeilian	Lower	Absent
		5. Hølonda Andesite
	Houin	4. Hølonda Limestone (fossiliferous)
Clanuirnian		3. Hølonda Shale
		2. Gaustadbakk Breccia + Almaas Mudstone
	Series	1. Venna Conglomerate
		Break
Skiddavian	Støren	3. Upper Støren Greenstone & Houe Slate
(Arenigian)		2. Jåren Beds
	Series	1. Lower Støren Greenstone

Carstens (1951) in Løkkenfeltets Geologi recognised three major groupings:

Houin gruppen

Bymark gruppen

Røros gruppen

Blake (1962), from graptolites found in the Bogo Shales of the Fgeldheim Beds in the lower Houins, showed this horizon to be equivalent to the phyllograptus densus zone (3b) of the Middle Arenigian.

The present author has recognised the succession given in Table II, in which the succession noted by Chadwick and Co. also is summarised. The stratigraphy remains fairly constant over the area and can be extended eastward into the ground described by Vogt. Table II shows the suggested correlation between the two areas. A less detailed correlation between the area described and that dealt with by Chadwick and Co. also is shown.

TABLE II

Carter	Vogt	Chadwick and Co.
Upper Arenaceous (sandstones & grits)		Nyplassen Beds (shales & sandstones)
Porphyrites (intrusive &/or extrusive)	Hølonda Andesites	Intrusive Porphyrites
Shales and Limestones	Limestone Shale	Fjeldheim Beds shales limestones sandstones
Lower Arenaceous limestones & sandstones grits conglomerates	Gaustadd Breccia & Almaas Mudstone	
Conglomerate & Sandstones	Venna Conglomerate	Fjeldheim Conglomerate
TUFFS	(Not mentioned)	STOREN GROUP (sedimentaries, volcanics, pyroclastics)
LAVAS (undifferentiated lavas	Storen Series	

The table shown is constructed on a structural and lithological basis rather than a stratigraphic basis. The porphyrites are not considered by all workers to be interstratified in the Houin Group. No fossils were found in the area and therefore no correlations were possible from palaeontological evidence.

<u>Succession in the Sundet Area</u>

The lowest beds in the Sundet Area belong to the

Støren Group, which are a group of basic volcanics commonly termed greenstones, and also possibly including some sedimentaries. The boundary with the overlying Støren Group is marked by a thick conglomeratic sequence; various authors appear to have fixed the actual boundary at different levels in this sequence. The present author regards the exact fixing of this boundary as impracticable, as no fossils are found and most conglomerates are, by their nature, diachronous. Never-the-less, the difference is very noticeable between the basic volcanics of the Støren Greenstone and the sedimentary rocks above.

The sedimentary Hovin Group includes thick conglomerates, grits, tuffs, sandstones, shales, and limestones. Any one broad lithological unit may extend along the strike over the whole area. However, individual bands of any rock type may disappear along the strike, probably due in most cases to facies changes. The stratigraphical position and nature of the Porphyrites is much in dispute, but structurally they lie near the top of that part of the Støren Group represented in the area.

STØREN GROUP

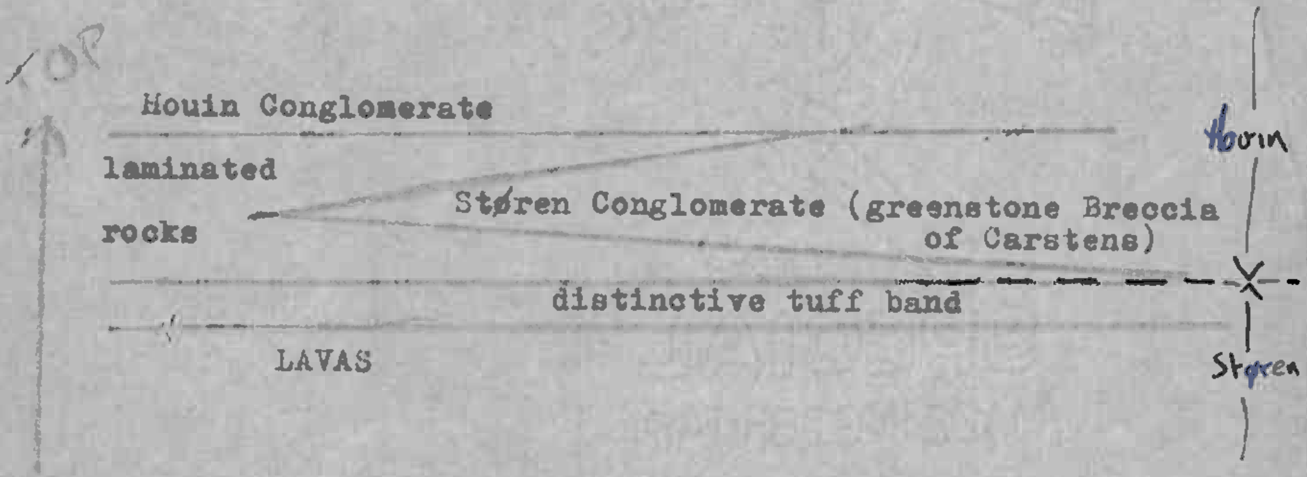
The Støren Group crops out in three parts of the area. The Støren Greenstones are typically basaltic and are epidote rich.

At Snoton in the North West a small inlier of lavas appears to be overlain by green shales which are followed by conglomeratic Houin sandstones with no marked unconformity.

In the North East at Krokstad Saetar another large inlier of lavas occurs. The north western boundary is not seen, but the eastern boundary is well marked, with a distance of only some 20 m. between outcrops of definite lava and typical conglomerate respectively. The inlier reaches a maximum width of approximately 1 km. in this area. A distinctive tuff layer in the greenstones occurs near to the south eastern boundary.

These Støren greenstone inliers are of great aid in determining the structure and stratigraphy of the northern part of the area.

Taking Carstens (1952 . Karte over Løkkenfeltets) Støren-Houin boundary to be correct through the lake Suorksgoen, the Støren would appear to include a sedimentary sequence at the top. A diagram indicating the stratigraphy of the Støren of the western shore of Suorksgoen is given below.



The lavas are epidote rich basic lavas and include massive and pillow varieties. The pillows have an epidote rich shell just inside the surface; this shell occupies the core of smaller pillows. Due to the sagging into earlier pillows of later more plastic ones, the characteristic " "-ing gives excellent younging evidence and show the Støren of this area to be inverted. The pillows lie in an apparently amorphous or cryptocrystalline quartz matrix which, due to its red nature, has been termed Jasper.

The distinctive tuff has large idiomorphic crystals of felspar and quartz in a fine grained matrix mainly of white mica, which is probably secondary alteration after fine grained felspar. Chlorite has developed in cracks and round the edges of the diomorphic crystals. The band is variable; having only scattered idiomorphic crystals ~~mfxix~~ in some outcrops, but being predominantly composed of these crystals in other outcrops. It is constant along the strike for over 1 kms and is very similar to the tuff band described near Krokstad Saetar.

The laminated fine grained beds are probably predominantly sedimentary but could in part be laminated lava flows; heavy alteration makes this difficult to decide. The conglomerate differs from the lower Houin conglomerates only in that the jasper shows very ragged edges in places. These edges probably result from the original position of the jasper as the matrix in between the pillow lavas. It may be that these conglomerates and laminated rocks above the tuff band in this area should be included in the Houin group. The junction between the lava, submarine flows, and the sediments is well marked but there is no clear distinction between the conglomerate in this area and the conglomerates which have been mapped by the present and previous authors elsewhere.

The major Støren inlier mapped by Vogt which crops out just to the East of the area mapped by the present author was examined whilst traversing over Vogt's Upper Greenstone-Jåren Beds-Lower Greenstone succession through Klegstad. The sedimentary Jåren beds were suggested by Vogt to be normally intercalated in the Greenstones unless major thrusting were to be inferred. The author here suggests that these are in fact normal lower Houin Group rocks lying in a syncline between the Støren Greenstone outcrops. The map produced by the author shows how these intercalated beds are a branch of the larger Houin outcrop to the southwest. The porphyrites, which Vogt regarded primarily as normally interbedded lava flows in the Houin Group, unfortunately wedge out along the strike in this syncline 1 km. southwest of Vogt's map area. Vogt would undoubtedly recognise the true Houin age of his Jåren Beds had these porphyrites continued along the strike to Klegstad in his map area (see fig. 1 and map).

THE HOUIN GROUP

The Houin Group is represented in the area mapped by four main sequences of strata which for convenience may be termed the Lower Arenaceous sequence, the Limestone and Shale Sequence, the Porphyrites, and the Upper Arenaceous. These names are strictly for local use in the area under consideration and are not being put forward as alternatives for the many names that have already been given for the rocks of the Lower Houin in the surrounding areas.

Lower Arenaceous Sequence

This sequence is made up of conglomerates, grits, sandstones and tuffaceous material with very local developments of limestone and shale. The sequence thins from circa 600 m. by Langgoen to circa 300 m. in the Jarengrenda.

The conglomerates rarely have a true framework of pebbles but more usually pebbles are scattered in greater or lesser quantities in an unsorted matrix. Poor sorting is general in this lowest sequence and in one outcrop grain size can vary from cobbles to grits and even shales.

Overall it can be said that the beds are coarser downwards. The pebbles are usually of Jasper (in the local sense of the word - amorphous quartz stained red), and green probably volcanic rocks ascribed by Chadwick & Co. to the Støren Greenstone lavas. The Jasper ranges up to blocks almost a metre in diameter in the conglomerate exposed in road cuttings along the north edge of Svorksgoen, and is often less well rounded than the well rounded rock pebbles. There is some mystery as to the origin of these jasper blocks and pebbles, the exposed greenstones not having Jasper either in very great quantities or large aggregates.

The beds sometimes show good sedimentary structures. False bedding for example is well shown in an outcrop on ~~the south shore of Morsgoen~~ the hill just west of Sundet. An outcrop on the southern shore of Morsgoen shows a sharply defined layer of pebbles lying on fine sandstones, but grading upwards gradually through grits with scattered pebbles into sandstones, over a vertical distance of 2 m. What appear to be turbidite units 30 cm. thick with grit bases and shaly tops occur in the valley north of Sgomoen and examples of load casting occur nearby. All these structures provide excellent younging data.

A large area of the Lower Arenaceous sequence occurs to the north of the major porphyrite outcrop.

~~The large area to the north of the major porphyrite~~
~~outcrop is an area~~

A large outcrop of the lower Arenaceous sequence is brought up by the Northern limb of the syncline which runs from Boverdalshaugen in the West to Klegstad in the North East. The large area of this outcrop, an area containing Reklorli and Morsgoen, is due to the many fold axes which repeatedly bring it to the surface. The rocks are essentially similar to the rocks of the Southern limb of the syncline bx but lime nodules occur and even marble beds outcrop. The conglomerates are of less importance and a grit with pale green grains scattered in the matrix is very common.

The rocks in the fault block to the south of Morsgoen are all conglomeratic, steep dipping and of great thickness unless they have suffered intense parallel folding. They include very few sand and shale horizons, and the age of the rocks of this block cannot be determined as the top and bottom are unseen. They are however lithologically very similar to the conglomerates of the Lower Arenaceous and are therefore considered here.

The exposures along the road by Blokkan and Estenstad in the Jårengrenda are of a very hard, pebble free, occasionally gritty, grey-green sandstone. This also occurs in the hills to the southeast. The continuation of these beds to the north east at Restad shows a more typical slightly schistose conglomerate, containing also some lime nodules.

In the above descriptions such names as "sandstone" have been used in the lithological rather than the mineralogical sense of the name, the name being used to denote grain size and method of deposition. The grains include a wide range of minerals and rock fragments, but quartz and alkali felspar grains predominate. Heavy minerals also are common sedimentary constituents. In fact some of these rocks could be water-lain tuffs. As many conglomerates occur in this area and are usually local developments, it would be incorrect to attach any of the proposed names for the various conglomerates of the Lower Hovin in surrounding areas to the conglomerates cropping out in this area.

Limestone and Shale Sequence

It is convenient to take together the limestones and shales which lie above the Lower Arenaceous Sequence; as their outcrops suggest they are local developments within the same general horizon. The sequence varies in thickness from over 300 m. in the Jårengrenda to nil in the far west.

Limestones develop locally at or near the top and bottom of the sequence and can continue along the strike in places for quite considerable distances. The limestones can be white, grey or black, always recrystallised, and coarse or fine depending on the amount of recrystallisation. It is therefore usually difficult to ascertain their original form of deposition, although recognisable reef breccias sometimes occur for instance between Konstadløkken and Blokkan. The limestones also often contain "ruckled bands" of arenaceous materials which are usually about 1-3 mm.

thick. The bands are sedimentary features and illustrate well the plastic deformations of the limestones.

The shales are predominantly grey and sometimes green, and rarely show any good cleavage. Inclusions of flecks of an iron mineral said by Vogt to be pyrhotite often occur. Occasional sandy bands indicate the bedding, and the shales also sometimes contain lime nodules.

The Porphyrites

It is convenient to deal with the Porphyrites here as they occur, structurally, above the limestone shale sequence and below the Upper Arenaceous Sequence. The sheet varies from a maximum of circa 300 m. around Konstadlokken to nil near Klegstad.

The two pioneer workers in this area, Carstens,(C.W.), and Th. Vogt, clearly disagreed as to the stratigraphical relationships of the porphyrites. The former regarded them as intrusive and probably discordant in most cases, the latter regarded them as lavas normally interbedded in the Hovin Group. Vogt even subdivided the porphyrites stratigraphically into Almaas and Berg types, but he acknowledged a discordant intrusive relationship for a minority of the outcrops. Chadwick and Co. considered them to be mainly concordant intrusions. The present author considers the problem not solved and notes:-

(a) the porphyrites contain no phenocrysts in the bottom 2-3 cms. in outcrops at Boverdalshaugen and Konstadløkken.

(b) the phenocrysts are dragged out along the base of the porphyrite in the possible flow direction, near Konstadløkken.

(c) in places the limestone underlying the porphyrite appears to have been unduly heated so that it veins into the surrounding shales; good examples are noted at the tip of Ramsberget.

(d) half a kilometer north of Gåsbakken a wedge of limestone about 2 metres thick, is included within the porphyrite. From the basal contact, branching veins of coarser grained calcite cut through the ruckled arenaceous bands and finer grained limestone - suggesting infilling of cracks produced during contact metamorphism by $CaCO_3$ rich liquids.

(e) there is a distinct lack of any typical lava flow features or indication of separate flows in the porphyrites.

All the above data suggests an intrusive origin for the porphyrites but there are two lines of evidence for an extrusive origin for the porphyrites.

1. In the area mapped there is not the great amount of thermal metamorphism that would be expected from the emplacement of a sill which is 300 m. thick at its greatest.

2. There is often a prominant pyroclastic layer found just underneath the porphyrite. This layer is found in outcrops near the farms Engan and Konstadløkken and the

lake Blokkefḡ and elsewhere. The layer contains blocks of the underlying limestone, and typically twisted bombs of porphyrite, in an indefinite matrix which is often calcareous. These bombs can scarcely have been formed underground, displaying as they do the indications of flight.

Unfortunately the area mapped the top of the porphyrite is never seen in contact with the overlying sandstones. However, the main masses of porphyrite are fairly consistant concordant sheets of indefinite origin, lying between the Limestone Shale Sequence and the Upper Arenaceous.

UPPER ARENACEOUS - this sequence forms a continueus outcrop from Restad extending south west along the strike until they are cut off by the major fault south of Morsgoen. The beds are equivalent to the Restadgrötås sandstones of Vogts Jåren Beds. A green-white outcrop surface is given by the beds which are better sorted than the beds of the Lower Arenaceous Sequence, they form fine grits, sandstones, and some shaly bands. The sequence is about 150 m. thick with the top not seen.

Intrusive rocks

Definite discordant intrusions of porphyrite occur in the Hovin and Støren Groups. Outcrops occur:-

1. South of Langkgos in the Støren group by a lake side.

2. South of Langkgost in the Hovin conglomerates.

3. Near the Støren-Hovin "boundary" on the west shore of Svorksgoen in the Howin conglomerate. Here is contains pebbles from the conglomerate which it intrudes.

In none of these instances was baking of the country rock obvious, but the rocks into which they were intruded, being coarse arenaceous, would be unlikely to show the effects of great heat transfer. These dykes could have been feeders for the sheets above.

STRUCTURES

The structures are apparently determined by two fold axial trends. Chadwick and Co. found F_1 cleavage to be affected by F_2 fold axes. In the area under discussion the F_1 structures trend East-West in the western part of the area, and Southeast-Northwest in the northern part of the area. Fe structures trend S.S.E.-N.N.W. and were considered by Chadwick and Co. to be probably responsible for the change in trend of the F_1 structures. Although termed F_1 and F_2 in the Fjeldheim-Gåsbakhen area by Chadwick and Co. the actual chronological order of the structures could not be proved in the area mapped by the present writer. There were no actual instances found of small scale F_2 structures affecting F_1 structures - few minor structures being observed in either case. Large scale mapping suggests the F_2 did in fact follow F_1 and did cause the major change in trend of the F_1 structures.

Cleavage is poorly developed locally but is difficult to distinguish from bedding. In the sandstones rodding parallel to the F_1 minor fold axes is developed, minor F_1 folding is in fact rarely seen but proves the major structures where it can be seen. Tension cracks occur in the Lower Arenaceous of the western part of the area and have an average strike of 20°N. and dip 80-90° to the West, with a pole plunging 10° towards 110°N. They are, therefore, probably resulting from the F_1 folding - the pole being roughly parallel to the F_1 fold axes and rodding. Also tension cracks, quartz filled, occur lying in the plane of F_1 schistosity in chlorite schists in the quarry at the road junction near Rektorli. Many of the shear planes have a similar orientation, they often shear F_1 structures, and are probably related to F_2.

Because of the lack of good minor structural evidence, save for bedding orientation, a detailed structural analysis is impossible and only general trends and major structures may be outlined. Indeed the structural geology of the area has been worked out principally using the orientation of bedding planes and stratigraphic evidence. The minor structural evidence that is available however confirms the general analysis made. The use of stratigraphy in the determination of structure involves circular logic, but this is defensible on the grounds that the stratigraphy used correlates very well with the successions worked out by previous workers in surrounding areas.

The bedding planes, when plotted on a π stereogram show a broad scatter of points - indicating a wide range of bedding orientation. Orientation is better seen on a trend map which shows the folding to be similar with the axial planes dipping steeply to the south or southeast. The F_2 folding is also seen to be similar with the axial plane dipping steeply to the west.

The outcrops of the Støren greenstones to the south - west of Sverksjoen and to the southeast of the Jårengrenda appear to lie on the cores of anticlines which may once have been continuous. Both climbs are overturned and dip inwards very steeply, usually 80^o. The F_1 fold axial planes indeed appear to swing past the vertical over the anticline - so that south and east of this the axial planes dip steeply to the north and northwest.

The nature of the F_2 "syncline" cutting across the F_1 anticline described above, is difficult to examine. F_1 structures in general appear to plunge 10-20^o towards this syncline from evidence in the area under discussion and from Vogt's mapping. The F_2 syncline which causes Hovin Series to be folded down across the probably previously continuous anticline with the Støren Series core, could then be interpreted as a broad warp at right angles to the main trend. However, evidence from the limbs of this syncline around Konstadløthen in shales and limestones suggest a tightly folded syncline. As this tightly folded syncline could be the centre of a broad warp, the two are not incompatible. Also the western limb of this 'syncline' has been cut out by a fault in the area mapped by Chadwick & Co. The eastern limb appears to have reorientated F_1 structures - which around Gåsbakken run parallel to the F_2 structure.

The interference of these two fold phases (which may or may not in fact be contemporaneous) produces an extraordinary structure to the north of Sjomeren. This is apparently a synformal anticline, i.e. the rocks young outwards but dip in towards the axis. Both north and east limbs are overturned and are due, respectively to F_1 and F_2 synclines. The overturned nature of the northern limb is determined from the arrangement and dip of the beds, the eastern limb is seen to be overturned from such sedimentary structures as load casting and graded beds.

The only obvious major faulting is that produced by two parallel faults striking W.N.W.-E.S.E. located just south of Morsjoen, cutting across the probable junction of the F_1 and F_2 synclines. The rocks within the fault block are lithologically very similar to the conglomerates of the lower Arenaceous Series, and if they are equivalent to these it suggests that the centre block is upthrown. The faults appear to die out rapidly in both directions and may in fact form some sort of wedge. Both faults are well marked by cliffs - sometimes very high, rows of bluffs, troughs and boggy ground. Reasonable exposure on both sides of the faults shows different beds finishing abruptly against the faults. There was no exposure of the actual fault planes but the consistency of strike of the fault lines across hilly ground shows them to be nearly vertical.

Stereoscopic photogeological interpretation was of little aid save in confirming general structural trends.

Metamorphism. The metamorphic grade rises ffom chlorite facies in the south to Biotite in the north. However the small nature of such a rise and the small number of smaples sectioned (18) do not permit the recognition of isograds. Amphibole growth is well shown along plames of parting in the rocks near the road junction south of Rektorli - the parting appears to be parallel to the bedding.

Many of the rocks are epidote rich, the sandstones especially being very often rich in secondary epidote - indicating an originally calcareous nature. The epidote appears to be concentrated in the coarser sand.bands and this ~~xxxxxxx xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx~~ emphasises bedding and is well illustrated in road cuts beside Blokkelj. The epidote crystals are idiomorphic. Lavas etc.

The porphyrites have generally been much altered with the olivines and plagioclases usually not in their original state, the plagioclase is often completely replaced by sericite. Samples from near Trotland show calcite occupying cavities in very much altered porphyryte.

Acknowledgements

I am happy to acknowledge the friendly aid of Per Sandvick and the Orkla Grube Aktiebolag, and the experienced judgements on my work and ideas in the field by Janet Seton Peacey, the criticisms of the staff and postgraduate students of the Geology Department, Imperial College, ~~and~~ My sincere thanks go to the Knubben family of Sundet with whom I stayed during my work in the field.

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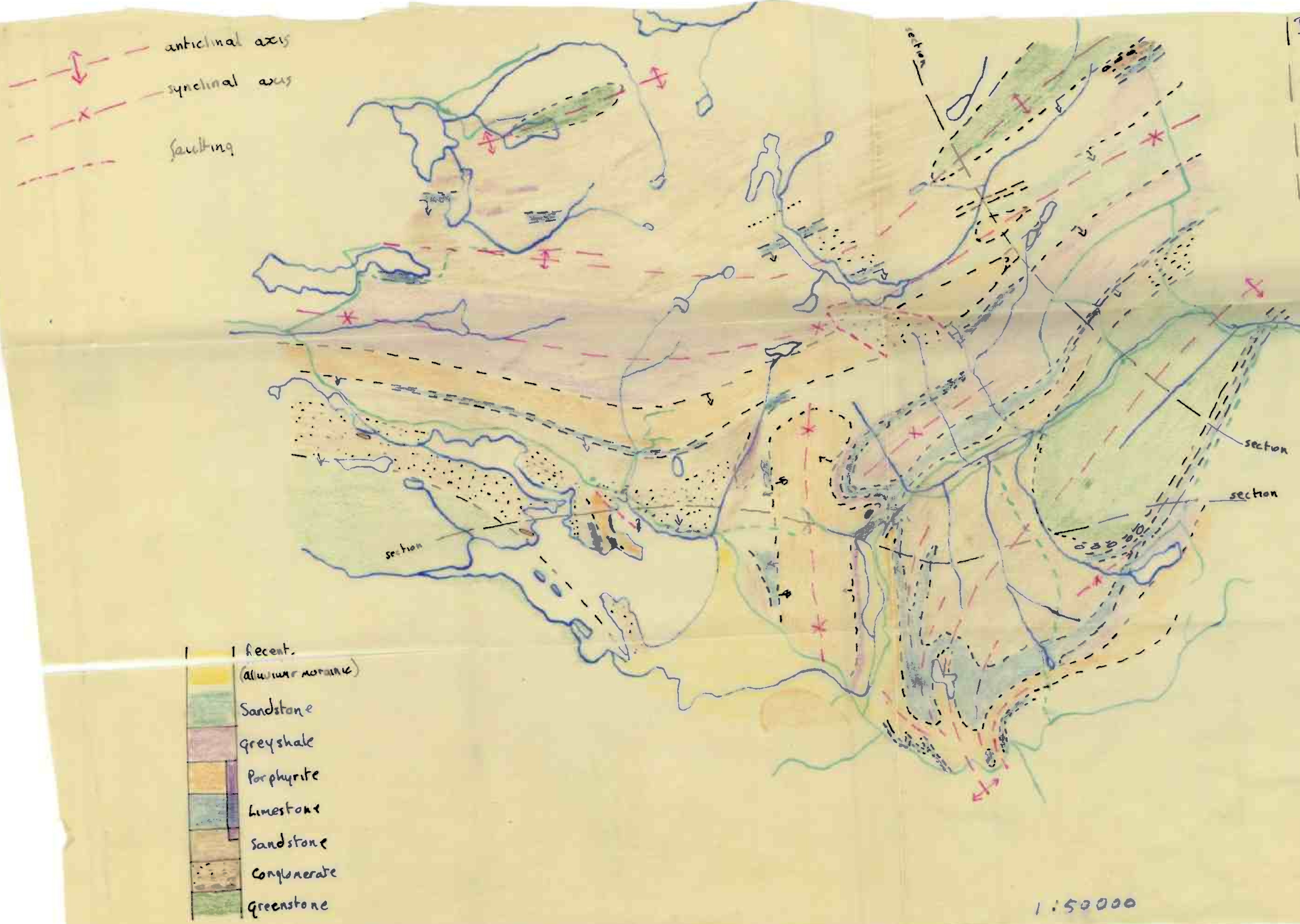
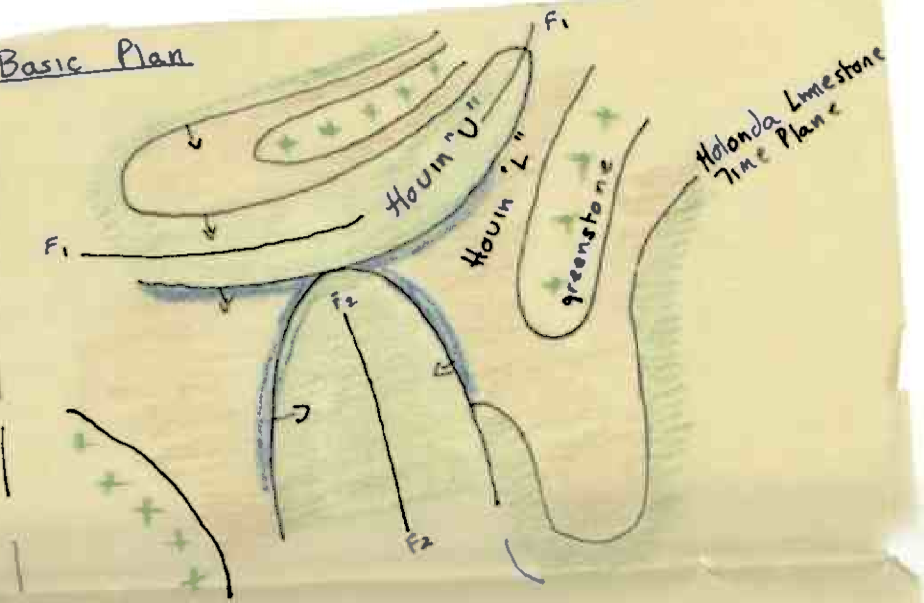
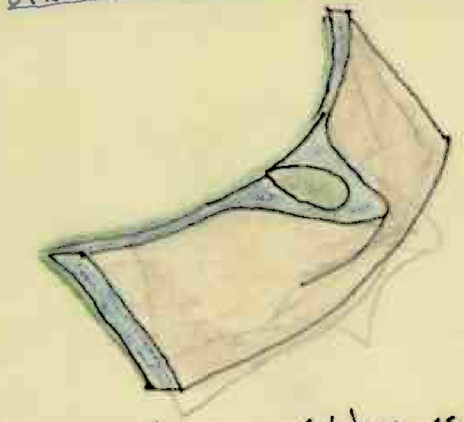


Basic Plan



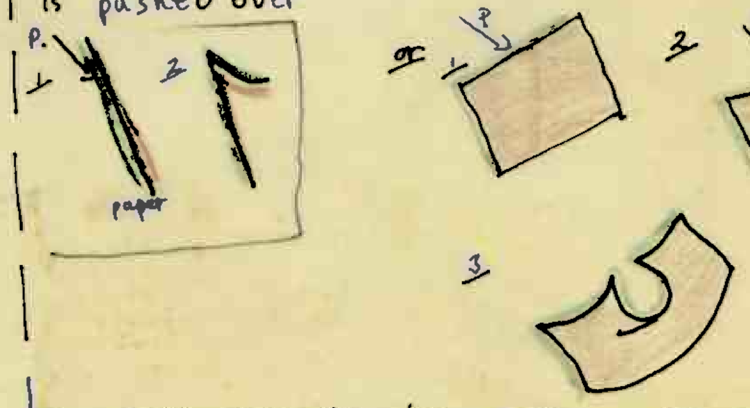
STRUCTURE Envisaged

Seen in 3D, a block diagram.



Produced by refolding isoclinal beds about a vertical fold axis striking ≃ 140°.

To obtain, slant piece of paper at 60° to vertical, & apply pressure from behind so top of paper is pushed over



Thus slight anticlinal bend (2) & tighter syncline (3) obtained.

Dear Per Sandvick, a word of explanation is needed I think with the sketch map. It is not absolutely final, maybe more complication will arise during the drawing up in London. You may find also the anomaly of an anticline next to an anticline, with no apparent syncline between, the syncline in question may be difficult to show on the map but will show up on a more detailed map.

Also in the Gasbakken area the generalised structure is shown, much minor folding complicates the surface out crop considerably. Also the main eastern greenstone anticlinal axis passes along the strike into a synclinal axis, the anticline dividing & flattening out, near Gasbakken. The main ~~we~~eastern greenstone I have borrowed from Vogt, but have done traverse across it to check it.

In the North East I cross swords with Vogt. His intercalated beds are definitely a continuation N. Eastwards of the Lower Houin. I even found the basal Houin conglomerate up against the greenstone. This also brings Vogts Upper & Lower greenstones into disrepute.

I believe all, or very nearly all, of the limestone is Holonda lst, be it white grey or black, more metamorphosed to the N - to a white marble usually. In some lst. areas all lst. types were found together - giving support to this idea.

In the much covered & ∴ less detailed Northern boundary I believe that the Lower Houin is repeated under a major synclinal axis rather than a straight succession into upper Houin, this fits much better with the structure & the greenstone inliers.

In the West, Carstens greenstones & Röros are non existant, this last confirmed by Janet Peacey when I showed her the area. Probably more fold axis come in than I have shown, much minor folding having occurred. The western areas is largely sandstone & ~~sha~~ skifer (sandsten v. meta in places), ie N. of the porphyrite outcrop.

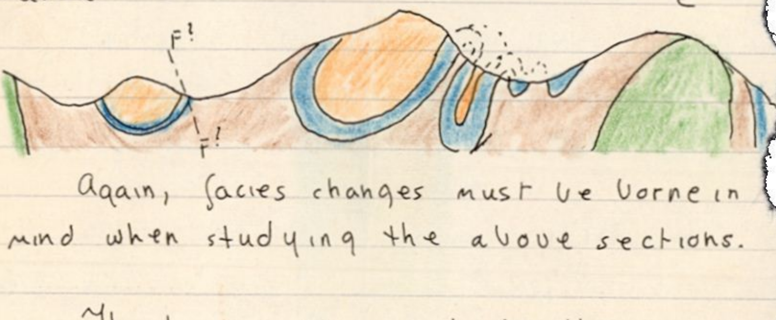
The grey shales are shown extending into the W. area, however they are more a facies developement & more meta hard sstn + slates occur in the W than grey shales. Also the grey shales can extend down thru the porphyrite into the sstn — I may be able to demonstrate a facies change across the area, which would be interesting.

The Carstens boundary Storen/Hovi[n] in the South West is correct but the exact position of the time boundary is difficult to obtain, I feel that there is no hard & fast line to be drawn.

The 2 well developed fold phases have produced v. interesting fold effects as shown, these remain to be worked out in detail but a general idea has been shown.

NE area NW SE

S. area W E



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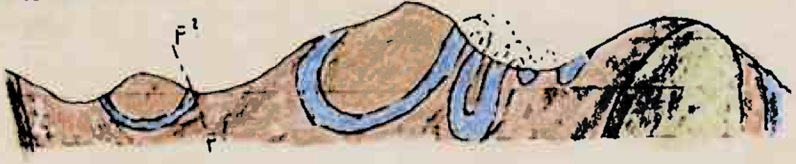

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Dear Per Sandvick, a word of explanation is needed I think with the sketch map. It is not absolutely final, maybe more complication will arise during the drawing up in London. You may find also the anomaly of an anticline next to an anticline, with no apparent syncline between, the syncline in question may be difficult to show on the map but will show up on a more detailed map.

Also in the Gasvatten area the generalised structure is shown, much minor folding complicates the surface out crop considerably. Also the main ~~western~~ eastern greenstone anticlinal axis passes along the strike into a synclinal axis, the anticline dividing & flattening out, near Gasvatten. The main ~~western~~ eastern greenstone I have borrowed from Vogt, but have done traverse across it to check it.

In the North East I cross swords with Vogt. His intercalated beds are definitely a continuation N. Eastwards of the Lower Hovin I even found the basal Hovin conglomerate up against the greenstone. This also brings Vogts Upper & Lower greenstones into disrepute.

I beleive all, or very nearly all, of the limestone is Holonda lst, be it white grey or black, more metamorphosed to the N - to a white marble usually. In some lst areas all lst types were found together - giving support to this idea.

In the much covered & ∴ less detailed Northern boundary I believe that the Lower Hovin is repeated under a major synclinal axis rather than a straight succession into Upper Hovin, this fits much better with the structure & the greenstone inliers.

In the West, Carstens greenstones & Röros are non existant, this last confirmed by Janet Peacey when I showed her the area. Probably more fold axis come in than I have shown, much minor folding having occurred. The western area is largely sandstone & ~~sha~~ skifer (sandsten v. meta in places), ie N. of the porphyrite outcrop.

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