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OXFORD UNIVERSITY

Svalbard
2001

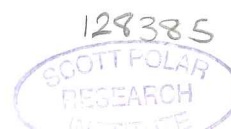
EXPEDITION

Final Report

Approved by the
Royal Geographical Society



and the
University Expeditions Council



Linnedalen

....to the North



....to the south

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introduction

The Oxford University Svalbard 2001 Expedition developed after Kirsty Tinto and Charlie Pearce formulated a plan to geologically map part of Svalbard and managed to rope in fellow Earth Scientist Natalie Lane before airing their plans at the University's Exploration Club meeting in October 2000, where they picked up the last member, Geographer Hannah Bienias.

Svalbard, an archipelago in the Arctic Circle of which Spitsbergen is the largest island, was chosen because of the interesting tectonic features found there and the (theoretically) good exposure, there being minimal soil and vegetation cover. Following discussion with an Oxford Postgraduate student who had been into the area, Gronfjord was selected because the map showed some large scale structures and we were interested in the small scale structures that correspond to this. It also seemed a logistically feasible area to study.

The main aim of the expedition was to map the area north of Kongressdalen, shown on the map below, with a view to understanding the kinematics involved in the regions faulting. Because of the unique position within the Arctic Circle, Svalbard experiences 24 hour daylight during Summer months, so the team also wanted to study the effects this would have on us psychologically, although this was carried out on an informal basis through diary writing. We also felt very strongly that we should minimise the impact we had on the environment in which we were studying and living, and researched the ways in which we could prevent disruption to vegetation and wildlife and dispose of our human waste.

The expedition was planned during the academic year 2000/01, most of which took place in the Lamb and Flag Public House or over (vegan) lasagne and chips in the Radcliffe Arms. Originally, we had intended to take six personnel but an unfortunate lack of interest coupled with, or maybe because of, the fact that we bonded as we planned and became a tight-knit team, meant that it was a group of four in the end who left Oxford in July 2001.

the team members...

Kirsty Tinto

Expedition leader

21 years old

3rd year Earth Scientist at Worcester College

- BSES Greenland '97 and subsequent training weekend, March/April 2000
- Undergraduate mapping project, July 2000
- Duke of Edinburgh Gold Award
- Mountain experience in the UK and USA



Charlie Pearce

Logistics Officer

21 years old

3rd year Earth Scientist at University College

- Undergraduate mapping project, July 2000
- Outdoor and rifle training with ATC
- Mountain experience in the UK and Alps



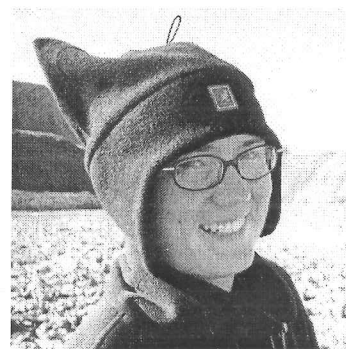
Natalie Lane

Environmental Officer

21 years old

3rd year Earth Scientist at St Peter's College

- Undergraduate mapping project, July/August 2000
- Mountain experience in the UK



Hannah Bienias

Medical Officer

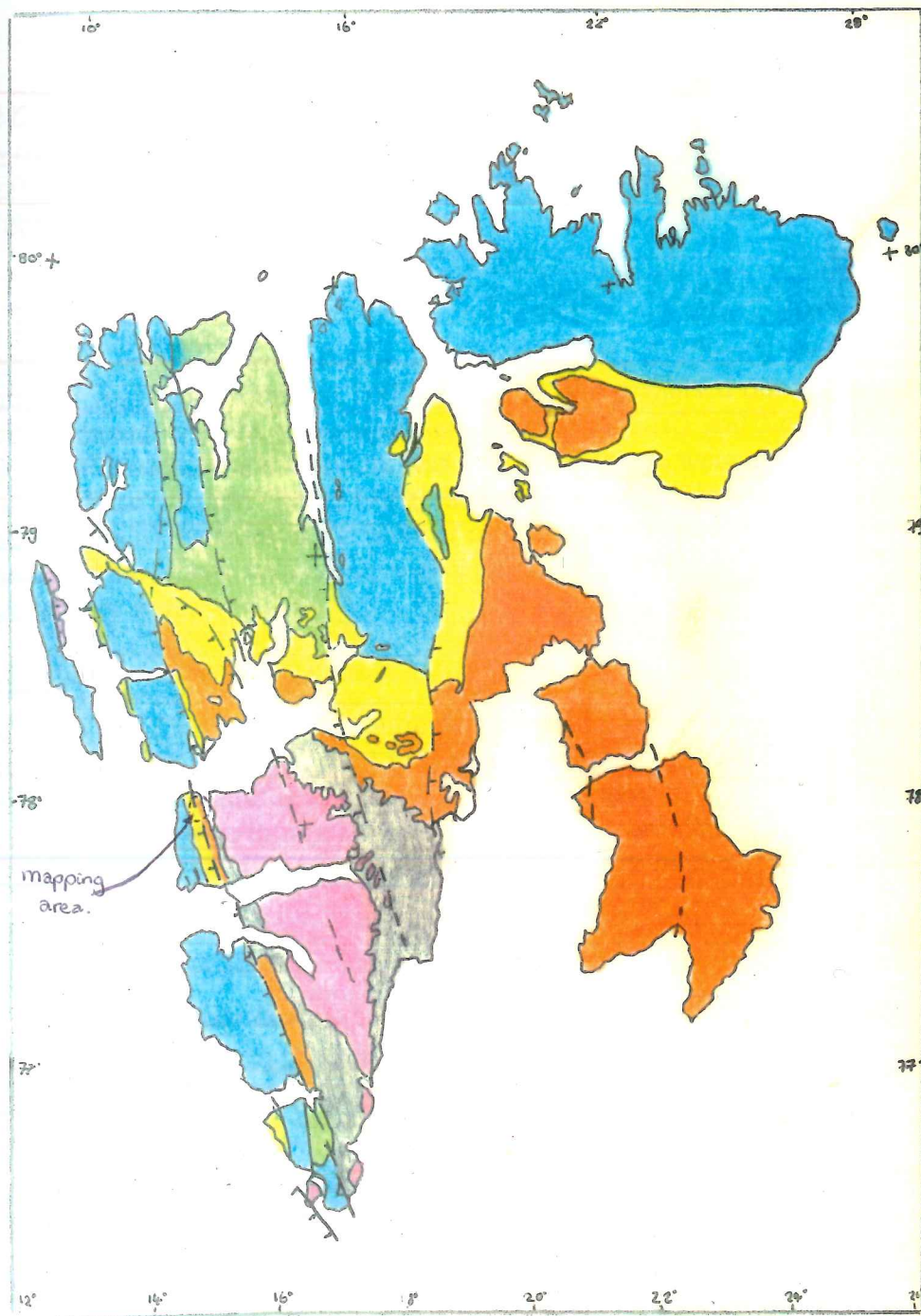
20 years old

1st year Geographer at St Catherine's College

- Duke of Edinburgh Silver Award
- Mountain experience in the UK and Alps
- Independent travelling during Gap Year



Geological Map - Svalbard



- Tertiary - pink
- Jurassic / Cretaceous - grey
- Triassic - orange
- Carboniferous / Permian - yellow
- Devonian - light yellow
- Hecia Hoek - blue

logistics

permission

Permission for any scientific fieldwork outside certain regions must be applied for from the Sysselmann, the Governor of Svalbard. Although we were within such a region, we checked that our proposals were acceptable anyway.

flights

Surprisingly there are daily flights to Longyearbyen, Svalbard's main settlement, which usually go via Oslo, Tromsø or both, as we did. We organised our flights through Campus Travel (although they have unfortunately since gone bust) and flew from Heathrow with SAS for £401 each, which was a lot less than the £700 we were expecting to pay. The flight left at 17.45 but we didn't get to Longyearbyen until 4.30am local time (Svalbard is one hour ahead of Britain), because of the number of connecting flights. This did, however, allow us to marvel at the architecturally impressive Oslo airport and attempt to buy 'Franks in a Bag', whatever they were.

freight

Apart from our food, all of our equipment was taken as hand luggage or in the hold of our plane. We decided to fly our food to Svalbard, even though it was slightly more expensive than shipping it, because it only took 7 days compared to 3 weeks and therefore gave us considerably more time to sort, weigh and pack our rations. We paid £2.75 per kilogram with Expedition Freight UK Ltd, plus an additional £65 for collection from Oxford.

Food

"There were only three tumblers, the water was so muddy that one could not make out whether the tea was strong or weak..." (Tolstoy, War and Peace)

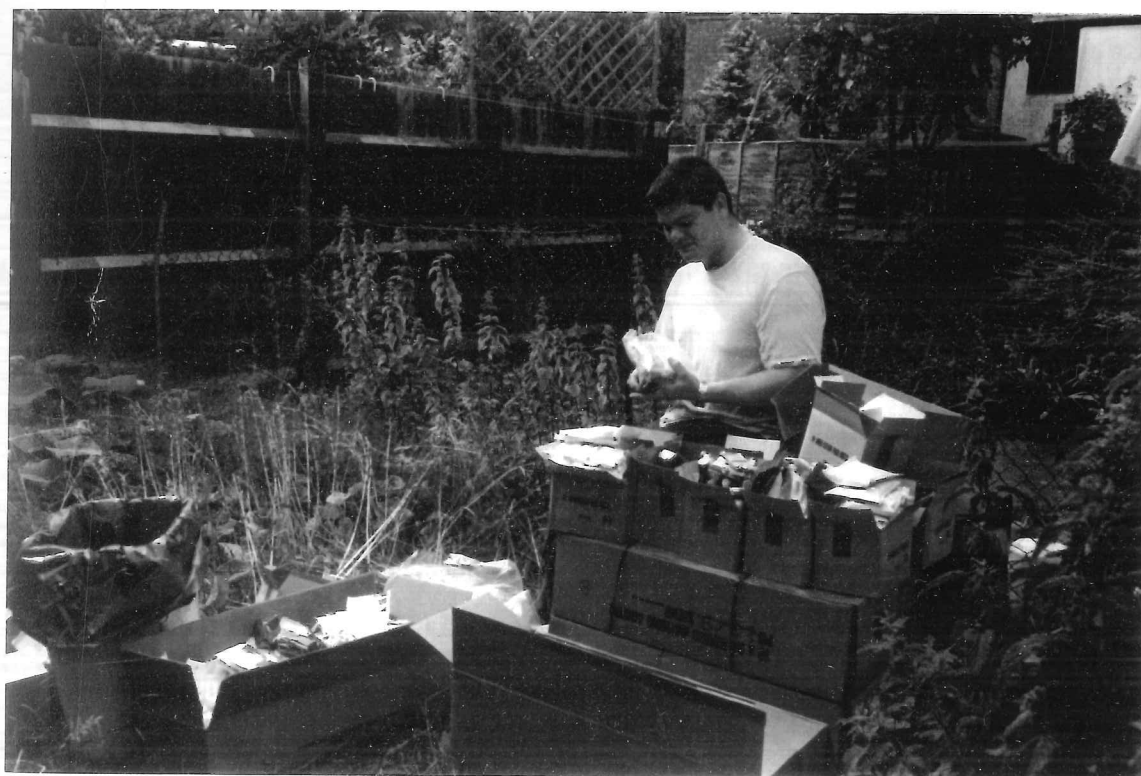
We bought our rations from John Hand, who specialises in selling ex-Army rations, most of which went out of date in 1990! Unfortunately due to BSE and Foot and Mouth Disease, there were restrictions on meat and dairy products being brought into Norway, and therefore Svalbard too, so we had to discard all of the main meals, tins of beef and pork paste and hot beef drinks. We replaced them with Beanfeasts and dried soya, which made cooking easier for us anyway as Natalie is vegan, and bought chocolate, salami and tubes of processed cheese in Svalbard Butikken supermarket in Longyearbyen.

Daily Rations

Breakfast: Porridge (*2 army rations worked well) + sugar

Lunch: Biscuit Browns (made Hannah very unhappy)
Biscuit Fruits

Army rations- sifting, sorting and testing for poison,
(with a little help from our friends).



Jacobs Crackers
Jordans Crunchy Bars
Jam, salami, tomato puree, primula, marmite (in a tube would be better).
Treats (skittles/poppets/crunchy bars)
Everyone required their own happy treats.

Dinner:

Starters: Soup or cous cous (with Tabasco)
Main: Mashed Potato or Rice or Pasta
Savoury Beanfeast or Soya Chunks or Bolognaise Beanfeast with
Tomato puree+garlic+Tabasco+herbs+chilli+peas
Pudding: Apple flakes, the more the merrier (can cause fights
between the crunchy fans and the sloppy addicts)

Biscuits: Fig Rolls and Bourbons (Yummy!!!)
Drinks: Tea, Coffee, powdered lemon and orange drink, a bottle of Irish Whiskey,
Hot Chocolate.

Auntie Kirsty's Special Irish Risotto-
'eat it all up now or the bears will get you'

4*rice
4*mushroom soup (more if you have it)
4*peas
1 bag of soya
Lots of water for rehydrating and major absorption.
MANY herbs, MUCH garlic.

Put them all in the pan at the same time and give yourself over to the whim of your stove. On a good day it'll be ready in five minutes, alternatively kick back with a good book and hope the peas are soft by breakfast.

- We didn't find the dextrose tablets very useful or appetising.
- Some of the army rations hadn't quite survived the ten years, specifically chocolate, nuts + raisins, some of the peas. Additionally, the tea was really rough and the non-dairy whitener was a joke. The toilet paper felt better than it looked.

accommodation in longyearbyen

We stayed at the only campsite in Longyearbyen, which is conveniently (and nosily) situated right next to the airport but is unfortunately a good hour's walk into town. We paid approximately £8 a night each and the facilities were excellent: toilets, hot showers and a heated cabin with cooking equipment. We used Maxi Taxis to transport our food and other gear to the quay where our boat departed, which were not cheap but saved us a lot of time.

boats

There is no road from Longyearbyen to Barentsburg, which is the town on the other side of the fjord to where we were planning to map, so we booked places on a tourist cruise that visited the Russian town through Spitsbergen Travel AS. We paid extra to be taken across Gronfjord in a RIB, although on our return journey we almost asked for our money back as all the rucksacks in the bottom of the boat were submerged in a mixture of seawater and

diesel. The tourist cruise did, however, take us incredibly close to a spectacular glacier that calved into the sea and the tumblers of whisky with real glacial ice cubes we were handed nearly made up for wet sleeping bags!

polar bears

The threat of polar bears is taken very seriously in Svalbard: anyone leaving the main settlements are required to carry a rifle. Consequently, we undertook a term's rifle training with the Oxford University Rifle Club using .22 rifles and a day's full bore training with .762 rifles at the National Shooting Centre in Bisley.

It is not necessary to have a license to hire a gun in Svalbard but you do need to show you have permission from the Sysselmann. We were able to hire two rifles from Spitsbergen Safari in Longyear and would pay for every bullet we used.

We also bought a box of ammunition for practice. We were advised to create a 'bear wire' around our tent, which consisted of two personal alarms attached to wooden posts with string running through the loops on the pins and two more posts to hold the string up at knee height. The theory was that if the string was tightened by a bear walking through the trap it would pull the pin out of the alarm and would a) frighten off the bear and b) alert us. It certainly worked: we were woken up on a number of occasions but to our relief it was only ever pesky reindeer!

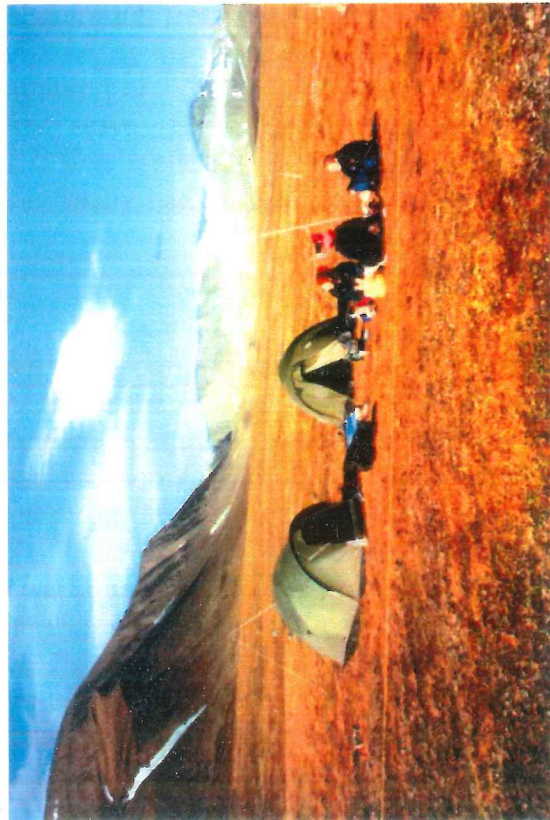
Because polar bears are curious and have an excellent sense of smell, there is a general consensus that any smellable item should be kept at least 100m away from tents, hence there was a nightly removal of all food, wrappers, medical kit and toothpaste to our stores. One of the most concerning moments came when we received a radio message one evening warning us that two polar bears had visited the camp of two geologists, 6km to the north of us, and they were last seen heading our way. We agreed to do a 'bear watch' all night, with two people patrolling our camp with rifles whilst the other two tried to sleep. This was one of the few occasions on which it snowed and we later discovered (thanks to the weather statistics on the web) that with wind chill temperatures reached -8°C during the night. To our relief, we didn't see any bears. The Norwegian geologists informed us over the radio that the bears had been relatively small and had been frightened of the sight of them and we found out a few days later that they'd been spotted again much further south.



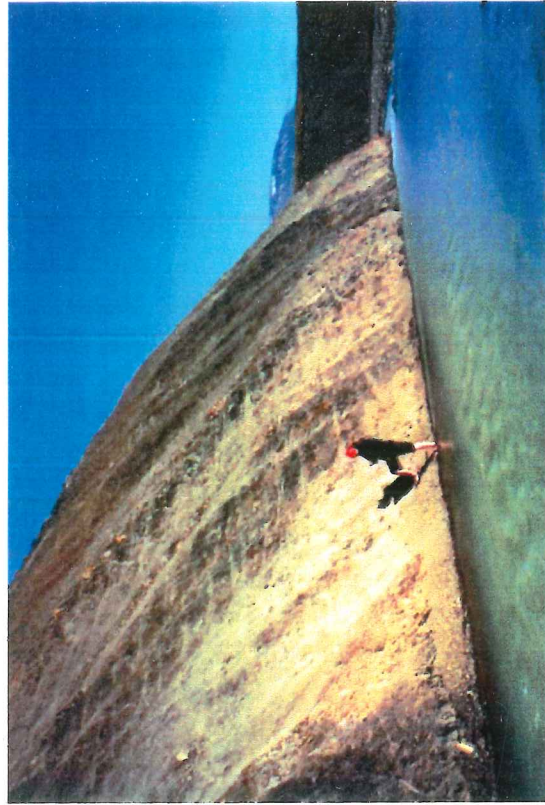
Charlie rifle training at Bisley



Our 'summer holiday' with views of Gronford glaciers



Base camp in Gronford



Kirsty mapping outcrop in Vastakelva river

equipment

tents

We hired two three-man Terra Nova tents from the British Schools Exploration Society (BSES) at a cost of £200 for the duration of the expedition. They were incredibly stable, even in the Force 6 winds we experienced on occasions, and were very spacious inside for two people and their kit. Sleeping four people inside was a bit more cosy but entirely possible and saved us from having to carry two tents when we went on our 'summer holiday' to the southern end of Gronfjord and to Kapp Linné.

radios & emergency beacon

We hired a radio from Norsk Polar Institutt, which cost us £225. Unfortunately we couldn't get the first radio to work at all so weren't able to make any contact with NPI until Jørgen brought us a new one on Day 3. After this, we had no problems at all and checked in to NPI every evening at 9pm, along with other groups in Svalbard, to hear the weather report and pass on any messages. We also hired an emergency beacon from Norsk Polar Institutt in case we were in real trouble.

stoves

We purchased two MSR Whisperlite stoves, at £60 each, which run on petrol, gas or paraffin, which we bought from Spitsbergen Safari in Longyearbyen. If you want to sell them back any unused fuel we advise getting a written agreement- we didn't and were left with several litres of fuel at the end of the expedition. Although both stoves worked well when tested in England, one refused to burn properly once in Svalbard and the other was extremely temperamental. We ended up with indigestion from pasta that had not been fully cooked and were having to spend several hours cleaning the stove each day. Luckily Jørgen was coming back into the field area at the beginning of Week 2 so we were able to get a message to him and he brought us a new stove. Unfortunately this also proved temperamental due to a deteriorated seal and it was replaced when Jørgen came back 2 weeks later – half way through our trip and we finally had a quick and reliable source of heat!

clothes

We were given a Wynnster Fastnet fleece each from our sponsors Adcocks, which was windproof, showerproof and extremely warm. One of the most appealing features was the lined zip which meant that the fleece could be pulled right up over the chin without contact with a cold metal zip. Helly Hansen also gave us each a thermal top which proved an excellent base layer and we were especially fond of our Mountain Craft waterproof trousers which were hard wearing, breathable and had full length zips. Combined with a pair of thermal leggings, our legs were kept perfectly warm and dry. We had to cross a lot of fast flowing rivers, of various depths, and found that walking sandals that can cope with getting wet were an excellent way of protecting our feet from stones and preventing our socks and boots from getting wet. We do recommend that all members have a pair – throwing them backwards and forwards across glacial streams has certain obvious disadvantages!

medical supplies & report

Books

Expedition Medicine (The Royal Geographical Society's handbook) eds. D.Warrell & S.Anderson

Wounds

Iodine tincture 25ml x1
Antiseptic wipes x 5
Betamide ointment 80g x1
Elastoplast strip 1m x 2
Melolin large dressings x 4
Melolin medium dressings x 6
Micropore tape x 1 roll

Bandages

Triangular bandages x 1
Crepe bandages x 6

Teeth

Lifesystems First Aid treatment for teeth:
Clove oil 20ml x 1
Dental mirror x 1
Unodent x 1
Packing wool x 3

Mini-kits x 2

Medium dressing x 1
Antiseptic wipes x 2
Assorted plasters x 20
Brufen 200mg x 12
Paracetamol 500mg x 12
Triangular bandage x 1
Crepe bandage x 1
Foil survival blanket x 1

2

Ears

Otosporin ear drops x 2

Analgesics

Paracetamol 500mg x 80
Brufen 200mg x 48
Tramadol 50mg x 10
Codeine Phosphate 30mg x 52
Diclofenac 50mg x 50

Drugs

Penicillin V 250mg x 28
Metronidazole 200mg x 63
Ciproxin 500mg x 12
Flucloxacillin 500mg x 100
Imodium 12 capsules
Piriton 4mg x 10
Flucanazoll x1

Miscellaneous

Laxatives x 10
Dioalyte sachets x 40
Water purification tablets x 100
Strepsils x 24
Lamasil anti-fungal cream x 1
Mycil athletes foot powder x 1
Cotton wool balls x 50
Cotton buds x 50
Tweezers
E45 cream x 2 tubs
Hydrocortisone cream x 1 tube
Indigestion tablets x 4 tubes
Cystitis sachets x 6
Anti-sting cream x 1

Eyes

Eye dressing x 2
Chlorophemicol eye ointment x

Emergency eye wash x 2

Eye bath x 1

We escaped very lightly injury wise considering the rocky terrain and scree slopes we were walking on. Charlie suffered from a painful Achilles tendon, for which she took anti-inflammatories but there was little else that helped except rest. Natalie sprained her wrist, which we bandaged up and put into a sling as she would insist on using it! We all suffered from upset stomachs at various points, including a bad case of indigestion due to semi-cooked pasta. The most curious medical complaint affected only Hannah and Kirsty's hands and looked at first like tiny red insect bites. After several days they became itchy and swollen, which restricted finger movement, before drying out and looking scaly and purple in colour. The only cream that helped the itching for some reason was anti-sting cream. We believe that they may have been chilblains.

budget

Income

McAlpine	500
St Catz. College	150
University College	500
Univ. Old Members	370
University Exploring.	820
AA Paton	700
Worcester College	350
St Peters College	350
Gino Watkins	1200
Personal Contribut.	2000
Mr J Parker	50
D Barton	20
Adcocks	200
Amec	50
Bidwells	100
	7360

Expenditure

Explore 2000	200
First Aid Training	50
Bisley	100
Insurance	260
Car Hire	50
Flights	1600
Tents	200
Army Rations (Arctic)	400
Cash + Carry	200
Stoves	160
Field Notebooks	30
Additional equipment	85
First Aid Kit	70
Medical Supplies	20
Rabies	120
Freight	525
Radios	225
Rifles	350
Fuel	50
Campsite	160
Boats	400
Norsk Polar Institutt	600
Longyearbyen Costs	200
Additonal travel	80
Photographs (films and develop.)	150
Production costs	250
	6535

The remaining £800 was returned to the Oxford University Expeditions Council, agreed as a condition of receiving the funds in the first instance.

expedition diary

Tuesday 17th July

Coach from Oxford to Heathrow.

Flight from Heathrow to Longyearbyen, which left London at 17.35 and arrived in Longyearbyen at 4.30 local time Wednesday 18th July.

Wednesday 18th – Friday 20th July

Organisation time in Longyear which was spent frantically hiring rifles and radios, buying additional meat, dairy products and paraffin and anxiously waiting for our food boxes to arrive from England.

Saturday 21st July

Boat from Longyear –Barentsburg (Russian mining town). We organised passage on a tourist boat in advance and negotiated transport from Barentsburg to our study area across the fjord with the boat company. They took us in a RIB, which involved two journeys due to the volume of equipment and food we had, but was very quick. Once deposited (fairly unceremoniously!) on the shore we began the difficult task of lugging our food boxes up slope to our chosen campsite. Due to the likelihood of polar bears using the shore to fish, we were advised to camp several hundred metres from the fjord and to keep anything smellable a similar distance from our tents. Our first problem was encountered when we came to radio check at 21.00: no matter how much we fiddled with the radio unit and wires, we couldn't hear anything except high-pitched crackles and were consequently unable to tell Norsk Polar Institutt that we were safe and well. Cooking posed our next problem. One stove refused to work whilst the other was temperamental. It took us several hours to produce edible, warm food, a theme that would reoccur throughout our trip.

Sunday 22nd July

Due to our radio problems we decided our only option was to walk to Kapp Linné, a radio station on the Western coast that, we had been told, was manned throughout the year. After a difficult 6 hour walk with one tent, the radio and food supplies, Kirsty and Natalie arrived at Kapp Linné first to find it deserted. Attempts to radio here were unsuccessful too so we camped overnight hoping that by morning someone would have arrived who could get a message to NPI. Despite these problems, Kapp Linné is a beautiful spot and the weather was excellent so our spirits were not dampened (much).

Monday 23rd July

To our disappointment, the radio station was still deserted by the time we left that morning so we taped a message to the side of one of the buildings in the hope that someone would return soon and relay them to NPI. We even posted a letter to NPI in the post box (we later discovered that it had arrived – 3 weeks later!) Took the coastal route back to our camp in Bendadalen, which was flat but extremely boggy and involved a number of river crossings. Once again, no luck with the stoves and even less with the radio. There was now the worry that we would be search and rescued on our 5th day, despite us all being safe.

Tuesday 24th July

Our fears looked like they were about to become reality when a helicopter flew low directly over our tents whilst we were cooking breakfast, but it subsequently disappeared. Less than

an hour later Jørgen from NPI arrived in a boat, mercifully with a new radio that worked! To our relief, he couldn't get the old one to work easily either. We toasted the sound of the voice of the NPI radio man at 21.00 with whiskey.

Wednesday 25th – Sunday 29th July

Our radio problems solved, we started the geological work and spent several days walking our field area and orientating ourselves before the actual task of mapping began. Kirsty and Charlie were forced to remain at camp on one day in order to clean and repair the stoves; neither stove had worked on the previous evening or that morning. Luckily Jørgen was coming out into our area in a few days so we were able to message NPI to request a replacement stove.

Monday 30th July

Received our 'new' stove, which sadly was also nearly defunct as the seal had deteriorated and it was difficult to maintain any pressure. It looked as if we had traded in a temperamental quick stove for a temperamental slow one! More dramas during the night: our bear alarms were set off but to our relief it was only reindeer.

Tuesday 31st – Thursday 2nd August

Mapping the shore of Gronfjord and Vasstakelva river.

Friday 3rd August

Bad weather forced us to remain in our tents for most of the day. Once again we were let down by our stoves half way through dinner.

Saturday 4th August

Despite the fact that it was still raining and the temperature had dropped several degrees, we decided we couldn't face another day in the tents. Mapped the upstream section of Vasstakelva river and were then invited in for dinner at the home of the three Ukrainian men who controlled the water supply to Barentsburg. Returned at 21.00 to receive the radio message warning us that two polar bears were in our area and spent the night pacing round the camp, anxiously scouring the horizon.

Sunday 5th August

To our relief, we didn't see any bears during the night or the following day. Because the Norwegian said the bears had been relatively small and frightened of the sight of them, we agreed that we wouldn't carry out another bear watch that night, but increased the size of our bear trip wire to give us more warning if they were set off.

Monday 6th August – Sunday 12th August

Logged the entirety of the Vasstakelva river in detail by pacing out distances between outcrops and taking across and back-bearings. Busy social calendar – we met up with the Norwegian geologists twice and received three new stoves when Jørgen came to collect them. Half way through our expedition and for the first time we had a reliable and quick stove!

Monday 13th August

Day off – walked to Kongressdalen lake to admire the stunning views over Linnévatnet.

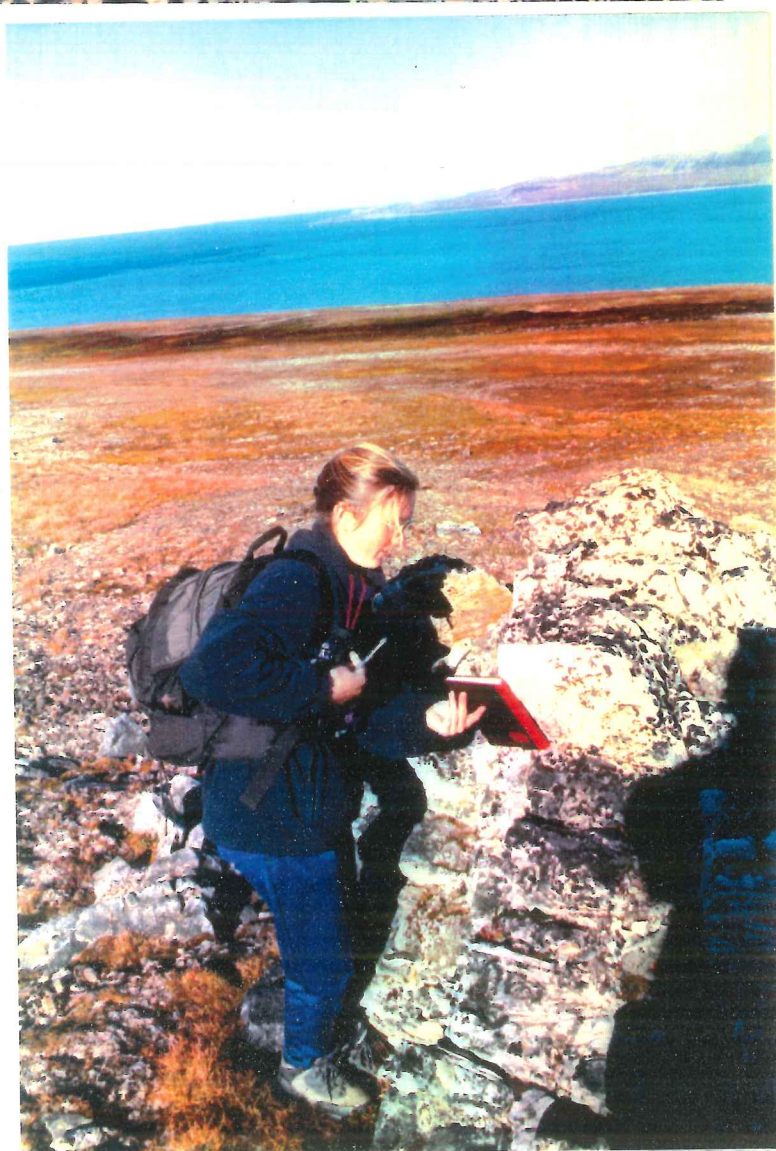
Tuesday 14th – Sunday 19th August

Charlie and Hannah spent Tuesday in the tents feeling a bit off-colour, whilst the others continued mapping. Logged the cliffs along Gronfjord from Blendadalen to Kongressdalen,

Pace and Compass



Strike and Dip



a section of the cliffs and two gullies north of Vasstakelva river. Experienced our 'cold period' with strong winds and some more sleet showers. Met two Glaciologists from the Institute of Geography in Moscow.

Monday 20th – Tuesday 21st August

Our 'summer holiday' – walked to the very south of Gronfjord, which involved the most difficult river crossing yet, and camped near to one of the spectacular glaciers. The return journey involved a climb up onto a ridge, where there were amazing views in all directions, and a swim in the fjord! It could be politely described as refreshing.

Wednesday 22nd – Sunday 26th August

Spent the week finishing off our mapping, including the substantial outcrops to the north of Stemmevatnet, the lake from which Vasstakelva flows. Walked to Festningen on Saturday evening, a beautiful spot at the mouth of Gronfjord, in order to see the sunset. Unfortunately it was cloudy and drizzly but we met our Geologist friends again and received presents of beer and jelly babies! From the 23rd the sun began to drop behind the horizon at night, but only for a few minutes so it still didn't get properly dark.

Monday 27th August

Our last day in the field! Packed everything up and dragged it down to the shore where we were collected by a RIB. To our surprise we were greeted in Barentsburg by the Russian glaciologists and were given a guided tour of the town as well as tea and cakes! We were also treated to a close-up view of a glacier that calved into the fjord on our return journey on the tourist. Our first night back in civilisation in Longyearbyen was memorable for the luxury of flush toilets and real mashed potatoes with butter and cheese.

Tuesday 28th – Friday 31st August

Showered, had slap-up feeds, returned our equipment to the relevant parties, did the tourist thing and bought souvenirs and began to write up our geological report. Our plans to pack up on Thursday afternoon and have a wild night at the local club before getting our 4.30am flight on Friday morning were scuppered by the pub closing at 11.30pm. Thursday certainly isn't the big night out in Longyear! After a long wait in the airport, we boarded the plane for Tromsø and eventually arrived in London at 12.30 on Friday.

top tips

- No flies: we were told that there would be masses and went prepared. Didn't see a single fly the entire time we were there.
- MSR stoves – they didn't work at all! They might be decent stoves if you are somewhere with no moss, wind, cold and a few team members with asbestos fingers. We were lucky to escape with any eyebrows between us, and had to endure a lot of indigestion from partially rehydrated food. But, they do make good pans!
- Have a pessimist and an optimist on your team, everything will go wrong but you will be able to deal with it.
- Try out all of your equipment LOTS before going. Just the once and it might just be a freak occurrence that it worked.
- Take as much string and tape as you can carry, it's good for a game and everything else. Zinc oxide is the best tape in the world.
- Sandals, crossing a river is no fun and very dangerous without them. Also, your feet will thank you a lot for the fresh air.
- A Shakesperian play, let your inner artiste run wild.
- Super treats-
 - Poppets.
 - Popcorn (cooks best when urged with the Indiana Jones theme music, Top Gun if you can't manage that)
 - Apple Tea
 - Tabasco, makes any food edible (apart from uncooked pasta)
- Having your stores away from your tents so the bears don't head straight for you. The further the better, but at least 100 metres.
- Tarpaulins are invaluable.
- Bear alarm- we did a construction job with personal alarms, wooden posts, 'Zinc Oxide', spare tent pegs. Make sure that you have plenty of spare batteries, they don't much like the cold.
- GPS, they really do work well and are very good for keeping track in notebooks if your field slips aren't very accurate maps.
- Wet wipes are a treat, and antiseptic handwash is sensible.
- Binoculars would have been really useful.

environmental issues

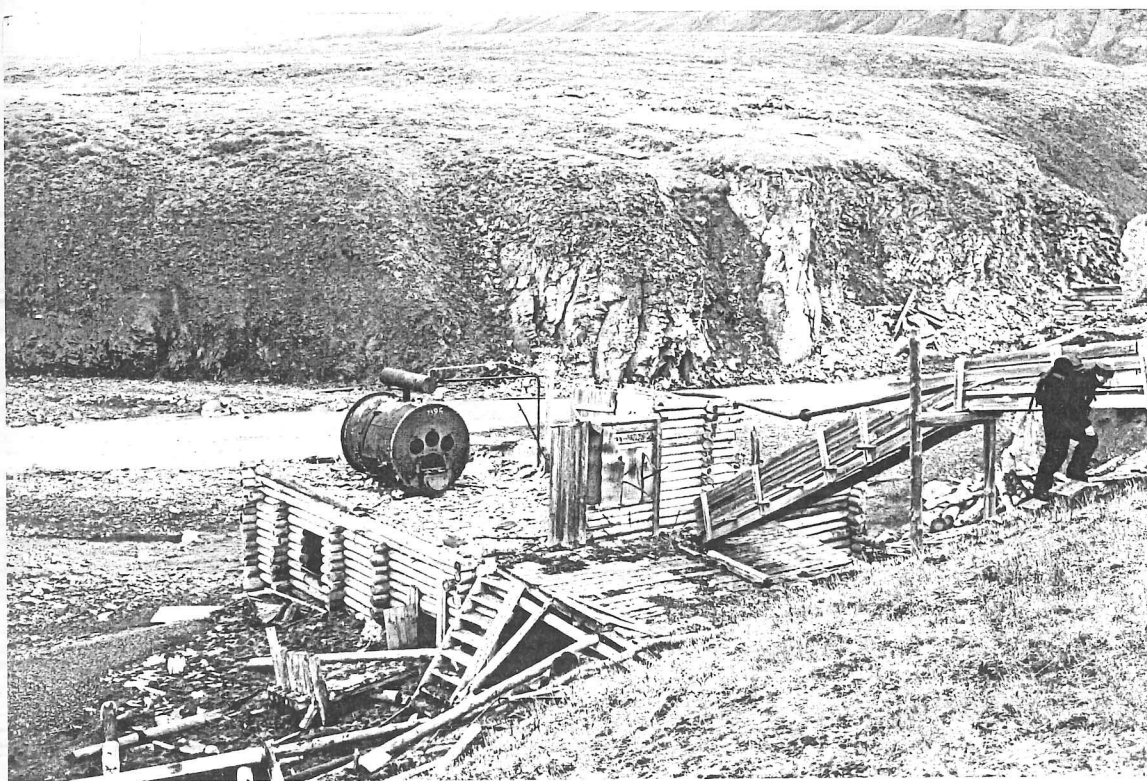
- We were amazed once in our field area by the amount of pre-existing damage in this 'pristine' environment. The Norwegian authorities had made it very apparent that we were guests and ought to be treating the land with the utmost respect. While in the field we came across a number of ruined buildings, lots of scrap metal and old wooden posts. Vehicles had also made a lot of damage once tracks were established the ground has a very poor recovery rate.
- Toilets – we read up on this subject before going and decided that the catlitter trench option was most suitable for our needs. We had a shovel that was left near the pit at all times to mark where it was. The ground was hard and the lack of moist soil meant that there was little advantage to digging a deep trench. As the weeks passed we adapted to the use of small holes which were easily infilled after use. The 'single-use hole method'.

We were careful to move the toilet area quite frequently to avoid generating paths and doing too much damage to a small area of ground. The toilet was well away from our drinking water source at all times.

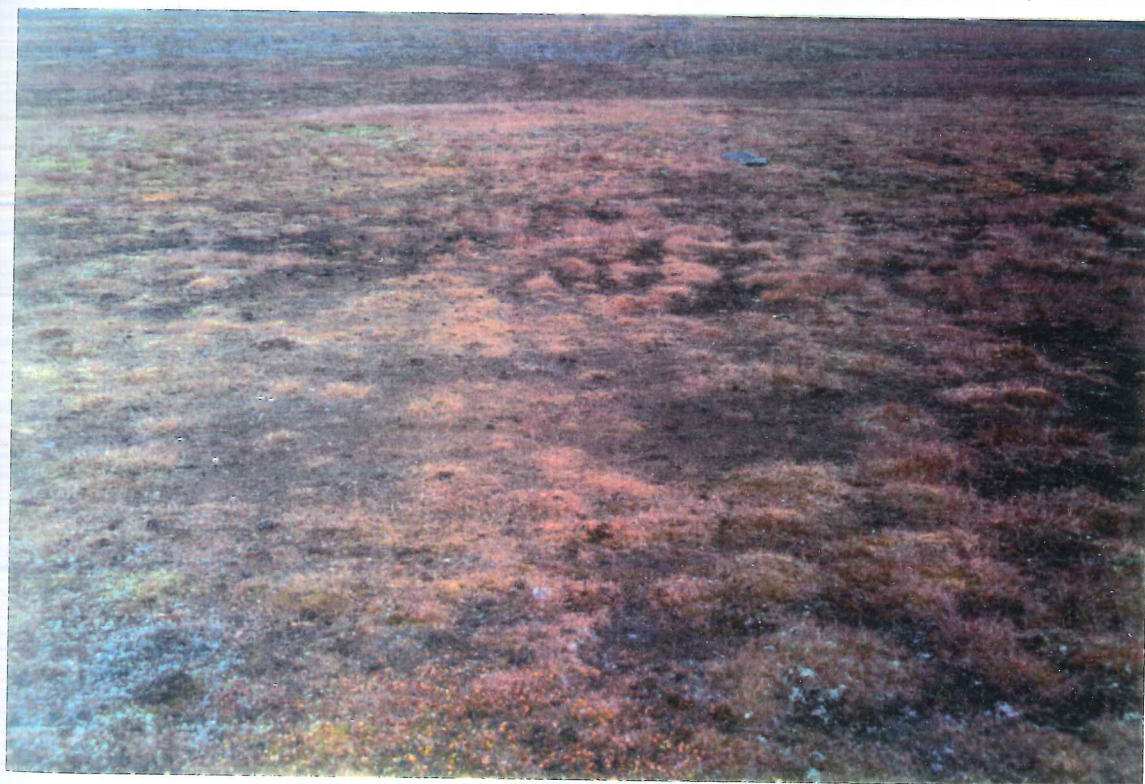
No non-human waste was buried in the ground.

- The ground cover was basically a very thin (few centimetre) layer of soil. This was topped in most places with moss and very little other plant life. In some places there were very impressive examples of patterned ground as a result of the freezing each year.
To try not to create too much lasting damage we moved the tents on a weekly basis. We shifted the tents sufficiently far that the routes we took into the tents wasn't the same. It was also necessary to shift the stores on a regular basis too. The trick was to move these things and yet also to have the stores at least 100 metres from the camp but within view, and also to have a good view around the camp in all directions.
- All of the non-human waste that we created we carried out of the field, following six weeks this was still only the equivalent of two boxes of rubbish. It was mostly the paper waste from the packaged dehydrated food and so compacted well. We did what we physically could to eat any food that was prepared, and then washed all of the crockery and utensils to remove food smells.

Prior human impact on the environment, abandoned
buildings and workings

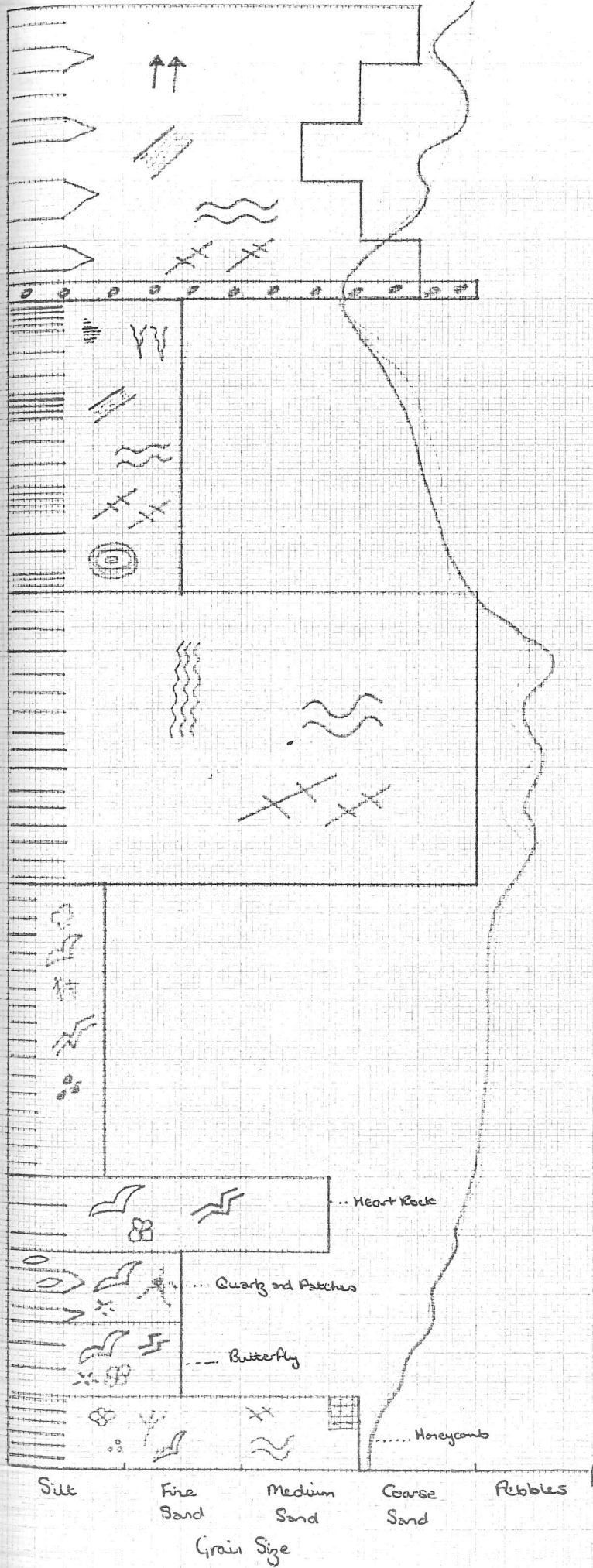


Frost patterning, doubling up as our toilet area.



The look of the land after we had moved our tents off it, some removal of mossy surface from beneath body of tents. No obvious paths.

Sedimentary Log



Making

Compositional

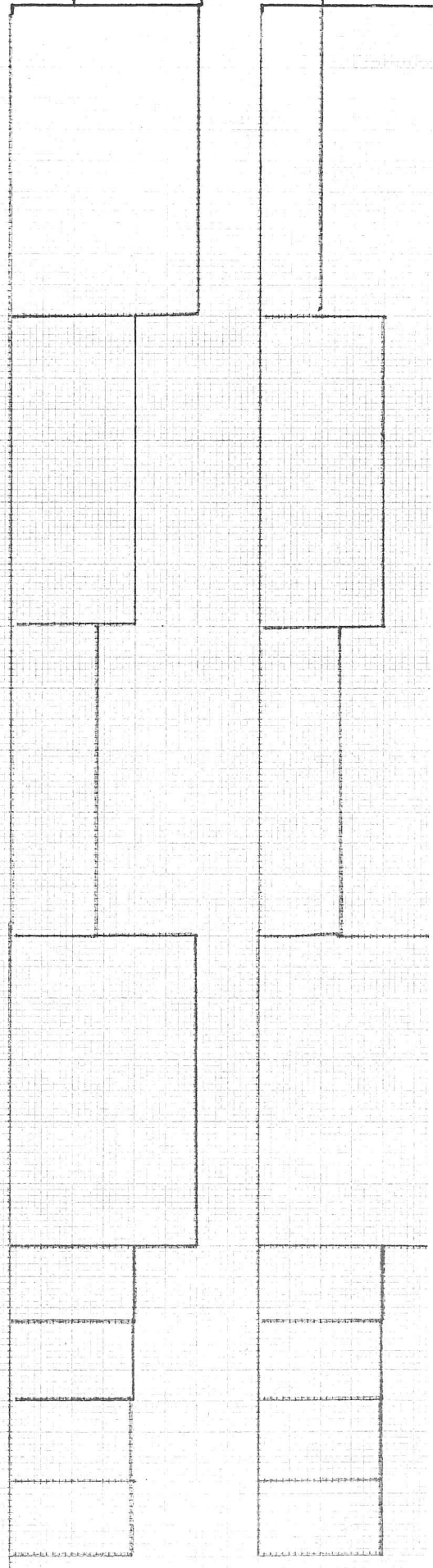
immature

mature

Textual









innovative

matu

















Key

Bedding

-  laminations
-  finely bedded
-  thickly bedded.
-  pinching out
-  lying upwards
-  ripples
-  cross-bedded
-  lenses

Fossils

-  wood fragments
-  brachiopods
-  sponge
-  corals
-  bryozoans
-  crinoids
-  shells
-  fragments.
-  burrows.

-  en echelon cracks
-  nodules.
-  chert
-  veins.
-  horizon weathering

lithologies

Formation: Gipsdalen

Name: Heart rock.

Colour: Brown, yellow.

Consolidation: Very well consolidated.

Weathering Surface: Lumpy on exposed surfaces.

Bedding: Regular, scale approximately 50cm. No laminations. Sharp contacts between beds.

Strike/Dip: 356/30°E

Composition-

Grain size: Medium sand.

Sorting: Fair.

Actual composition: Predominantly quartz, also iron, and must be some carbonate as it fizzes with acid.

Compositional Maturity: Semi-mature.

Textural Maturity: Semi-mature.

Sphericity: Moderately spherical.

Roundness: Sub-rounded.

Fossils-

Actual: Hearts and corals, quite dense. Whole fossils, not fragmented. 15-20% fossils. No specific orientation, random.

Trace fossils: None.

Veins/Fractures: en-echelon cracks, 028/75°NW 345/82°W

Sedimentary features: None

Way up? ???

Depositional Environment:

Coastal shelf, marine.

Name: Quartz and Patches

GPS: N 78°03'11.7"
E 013°56'22.2"

Colour: Grey, rusted orange patches.

Consolidation: Very hard.

Weathering Surface: Lumpy, rounded edges.

Bedding: Regularly bedded, 10-30cm scale. Pinching out within the beds, lenses of material. No laminations.

Strike/Dip: 325/34°NE

Composition-

Grain size: Fine in the blue layers, fine to medium in the orange.

Sorting: Good.

Actual composition: Quartz, iron rich, very dense rock.

Compositional Maturity: Fairly mature.

Textural Maturity: Fairly mature.

Fossils-

Actual: Little shelly ones, prominent ridges...brachiopod. Fragmented.

Veins/Fractures: Dense quartz veining which leads into the patches.

Sedimentary features: None.

Way up? ???

Depositional Environment:

Very shallow marine, verging on terrestrial, possibly lagoonal.

Name: Butterfly

Colour: Grey.

Consolidation: Very hard.

Bedding: Well bedded, thickness ranging from 10-30cm. No laminations.

Strike/Dip: 318/34°NE

Composition-

Grain size: Quartz and Calcite.

Fossils-

Actual: Brachiopods, coral, shelly fragments.

Veins/Fractures: Cracks, 060/35°SE

Comments: Smells like oil in a few horizons, possibly containing bituminous deposits.

Depositional Environment:

Shallow marine to coastal.

Name: Honeycomb

Colour: Vivid orange.

Consolidation: Hard.

Weathering Surface: Honeycomb.

Bedding: Finely bedded, 10cm thicknesses. No laminations.

Strike/Dip: 333/26°NE

Composition-

Grain size: Matrix is medium/fine grained, and well consolidated.

Actual composition: Heavily fossiliferous, in some places fossil supported. 70% fossil.

Fossils-

Actual: Corals, small circular fossils that may be ooids, crinoids, brachiopods.

Veins/Fractures: Not clearly visible.

Sedimentary features: Cross-bedding, ripple marks.

Way up? ???

Comments: The outcrop is falling to pieces which suggests that it may be well fractured.

Depositional Environment:

Delta fan.

Depositional Environment:

The sediments of the Gipsdalen group show a stratigraphic development from clastic, alluvial to delta fan facies in the lower part, though a fine-grained carbonate facies and into a cherty deposit, with possible dolomite.

Name: Kapp Starostin Formation

GPS: N 78°03'12.0"
E 013°56'29.1"

Colour: Grey, blue

Consolidation: Very well consolidated.

Weathering Surface: There must be iron present as there is a rust like staining to some of the weathered surfaces. The surfaces have a lumpy feel to them and are covered in lichen. It is quite weather-resistant and tends to form well-exposed crests and ridges.

Bedding: Pretty regular bedding on a 20/30cm scale. There are no laminations. The contacts between the beds are very distinct and planar.

Strike/Dip: 346/26°NE

Composition-

Grain size: Very fine.

Sorting: Perfect.

Actual composition: Quartz, doesn't fizz with acid. The rock seems to have a cherty lustre to it, implies metamorphosed material.

Compositional Maturity: Very mature.

Textural Maturity: Very mature.

Fossils-

Actual: Sponges, brachiopods, bryozoans.

Veins/Fractures: Cracking orientations, 050/85°NW 344/58°W
Way up? ???

Comments: Arenaceous cherts.

Depositional Environment:

This formation was deposited in a subsiding, low-energy, but oxygenated marine shelf environment. The maturity may come from a later period of metamorphism

Name: Vardebukta

GPS: N 78°03'16.9"
E013°58'31.8"

Colour: Pinky, brownny, grey

Consolidation: Well consolidated

Weathering Surface: Resilient, lichen covered

Bedding: Well-bedded on a 20/30cm scale. Alternating lighter and darker material and preferentially eroded holes forming layers. Not laminated.

The beds contain thin calcareous silt- and sandstone beds and grade upward in to sandstones.

Strike/Dip: 333/56°NE

Composition-

Grain size: Coarse sand. <1mm.

Sorting: Not very well sorted, smallest grains are fine sand (still visible with the naked eye).

Grading: No

Actual composition: Carbonate (fizzes gently with acid) and quartz. Brown grains of iron rusting.

80%-white, vitreous lustre, quartz/calcite

15%-porosity

5%-darker grains

Compositional Maturity: Not very

Textural Maturity: Not very

Crystallinity: No obvious crystal faces

Sphericity: Spherical

Roundness: Sub-rounded

Fossils-

Actual: None

Veins/Fractures: Regular system of small scale fractures with an orientation 060/79°SE

Sedimentary features: Ripples. Cross-bedding.

Way up? Right way up, as obvious from the ripples and cross-bedding.

Comments: Within the outcrop there is one random bed which doesn't appear to conform with the rest of the lithological description. It is 1/2m thick and grades upwards to medium sand grain size. It contains a large amount of shell detritus (possibly a death assemblage). It has a white colour and a large number of thin calcite veins running parallel to the bedding. The bed contains clasts of a very fine grained material which is orange and subrounded. There are also quartz clasts that are 4-5cm big.

Depositional Environment:

This represents a series of stacked transgressive/regressive cycles, but with the bulk of the deposition occurring in a high energy marine shelf environment.

Name: Kapp Toscana Group-Nodule Bed

GPS: N 78°03'16.9"

E 013°58'31.8"

Colour: Orangey/brown/grey

Consolidation: Shale is fissile, sandstone beds are well consolidated.

Weathering Surface: Lots of iron staining.

Bedding: Scale – varies between fine shale, on a <1cm scale, up to 15cm.

Regular, well-bedded. Laminations and sharp contacts between beds.

Strike/Dip: 24°N/322

Composition-

Grain size: Fine sand.

Sorting: Good.

Grading: None.

Actual composition: No fizzing with acid, and iron rich, so probably predominantly quartz with some mica.

Compositional Maturity: Fairly mature.

Textural Maturity: Fairly mature.

Crystallinity: Not very crystalline.

Sphericity: Too finely grained to tell.

Roundness: Too finely grained to tell.

Clast to matrix ratio: No clasts.

Fossils-

Actual: Some wood fragments.

Trace fossils: Trace fossils apparent on top bedding surfaces. Burrows lie parallel to the bedding.

Veins/Fractures: No veins or obviously oriented fractures.

Sedimentary features: Ripples, cross-lamination.

Way up? Cross-lamination suggests that the beds are the right way up.

Comments:

Sideritic nodules often found in beds. They are iron rich and very well consolidated. They are generally sub-spherical or with a slight elongation along the plane of the bedding. The nodules have internal concentric layering and range from 5-50cm in diameter.

There are additional large quartzite beds within the formation. They are finer grained than the quartzites in the Helvetiafjellet formation. They are blue in colour and contain veins of a darker coloured material.

Depositional Environment:

This formation was deposited in a predominantly nearshore environment and is characterized by shallow marine and coastal reworking of deltaic and fluvio-deltaic sediments. Terrestrial influx of fossils and wood fragments. The red colouration suggests lagoonal or very shallow marine environment. The sequence shallows upwards as it becomes increasingly more terrigenous, a regressive sequence.

Name: Helvetiafjellet Formation – Quartzite

Colour: Fresh surfaces are very pale, a creamy off-white.

Consolidation: Very well consolidated, very hard.

Weathering Surface: Pinkish/orangey staining – possible iron leaching from the nodule bed.

Bedding: Difficult to see, in certain outcrops it is 20-40 cm thick. Not regular, pinches out and is mangled a lot by post-depositional deformation.

Strike/Dip: 330/27°NE

Composition-

Grain size: Possible fining up sequences on a 5cm scale from coarse sand at the bottom up to medium sand at the top, visible with the naked eye.

Sorting: Not good.

Grading: Fining upwards.

Actual Composition: Mostly quartz and some iron.

Compositional Maturity: Mature.

Textural Maturity: Immature.
Crystallinity: Very good, highly crystalline.
Sphericity: Subangular.
Roundness: Not very well rounded.

Fossils-

Actual: Wood fragments.
Trace fossils: None.

Veins/Fractures: No apparent veining.

Sedimentary features: Ripples. Cross-bedding on a 10-cm scale.

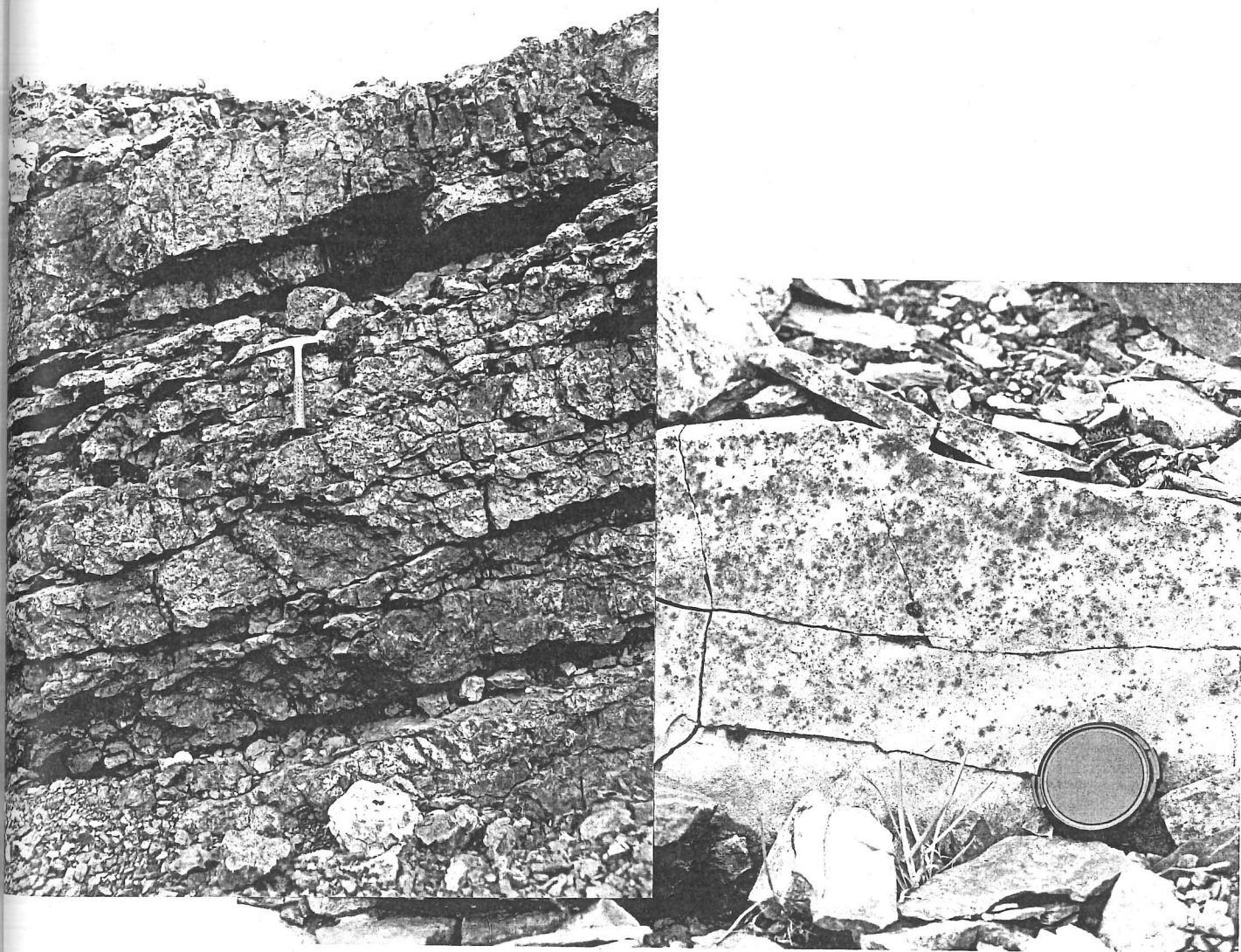
Way up? Ripples suggest that it is the right way up.

Comments: Contact between the quartzite and nodules is a conglomeratic bed approximately 50cm thick. Goes from clast supported at the bottom to matrix supported at the top. Maximum clast size is 10cm. Quite dense wood fossil horizon. Clasts: chert, quartz, random lithics. Matrix is coarse sand and quartz dominated.

Depositional Environment:

The conglomeratic section at the base is fluvi-deltaic, while the main section of the formation is coastal. The fining cycles represent a deepening and then shallowing sequence, repeated possibly on a Milankovitch cycle.

Good exposure of a series of beds within the upper Gipsdalen Formation.



Sedimentary features, ripples on a bedding surface in the Kapp Starostin Formation. (lens cap for scale)

regional tectonic history

The metasediments studied in the Grønfjord area were deposited over a period spanning from the Late Carboniferous to Early Cretaceous. Due to the strong overprint of Tertiary deformation and the consistently low (greenschist facies) metamorphic grade, distinguishing the different events is difficult.

Rapid facies changes in the Billefjorden and lower Gipsdalen formations have led previous workers to believe that a syn-depositional extensional tectonic regime prevailed during the Late Palaeozoic. However, the orientation of faulting to the North of this study area has caused debate about the direction of extension. These motions may be the result of the waning effects of the Caledonian orogeny, or alternatively a weak correlative effect of the Variscan orogeny developing far to the South.

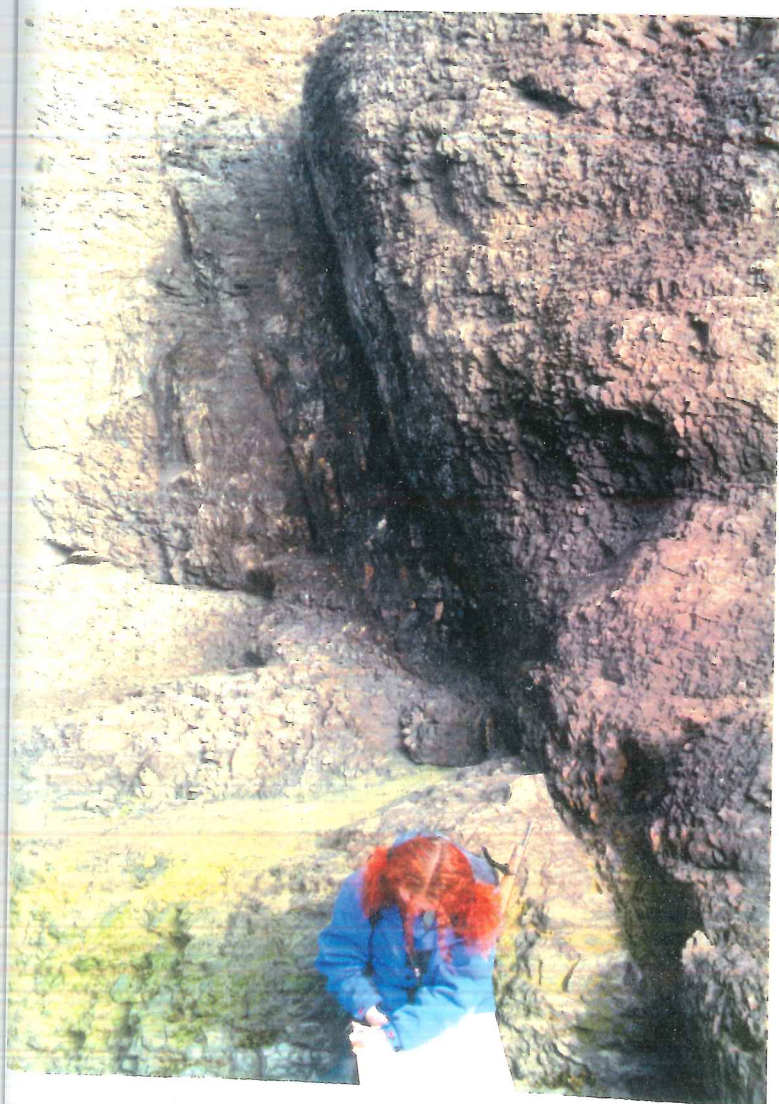
The Mesozoic era was dominated by epeirogenic movements, which resulted in repeated transgressions and regressions, the latter being characterised by a high input of coarse clastics. Extension was again occurring in the Late Mesozoic, as documented by local faulting and the intrusion of dolerite dykes in the region during the Early Cretaceous, and may have heralded the initiation of movements leading to the opening of the Atlantic and Arctic oceans.

No Tertiary strata were studied, but Tertiary deformation occurs throughout the region resulting from motion related to the separation of Svalbard from Greenland. This deformation is referred to as the West Spitzbergen Orogen and occurred in two phases:

1. An early phase of compression creating a fold and thrust belt.
2. A later extensional phase in the form of reversal of thrust faults. This phase is restricted to the far West of Spitzbergen, West of Linnevatnet, outside of the study area.

The NNW to NW trend of folds seen in the Palaeozoic and Mesozoic strata in the field are dictated by the Tertiary compressive regime, and many are truncated by NNE trending, WNW dipping thrust faults also created during this regime. During this complex interaction, bedding-parallel thrusts occurred in the incompetent shales resulting in thickening. This can be seen in the Bravaisberget and Janusfjellet formations, particularly at Festningen. In the competent beds, the deformation is more commonly taken up by small faults and by folding.

Large scale regional tectonic features, folding in the hillsides. Photo taken looking south.



Metre scale faulting in
Kapp Toscana Group

tectonics of the study area

Our study area extended from Kongressdalen in the South to Festningen in the North where we studied accessible outcrops from the coast to just beyond Stemmevatnet in the West. The most detailed study was along the river, Vasstakelva and the gullies formed by its tributaries. This part of Svalbard is part of the foreland region of the West Spitzbergen Orogeny and is predominantly deformed by folds and thrusts.

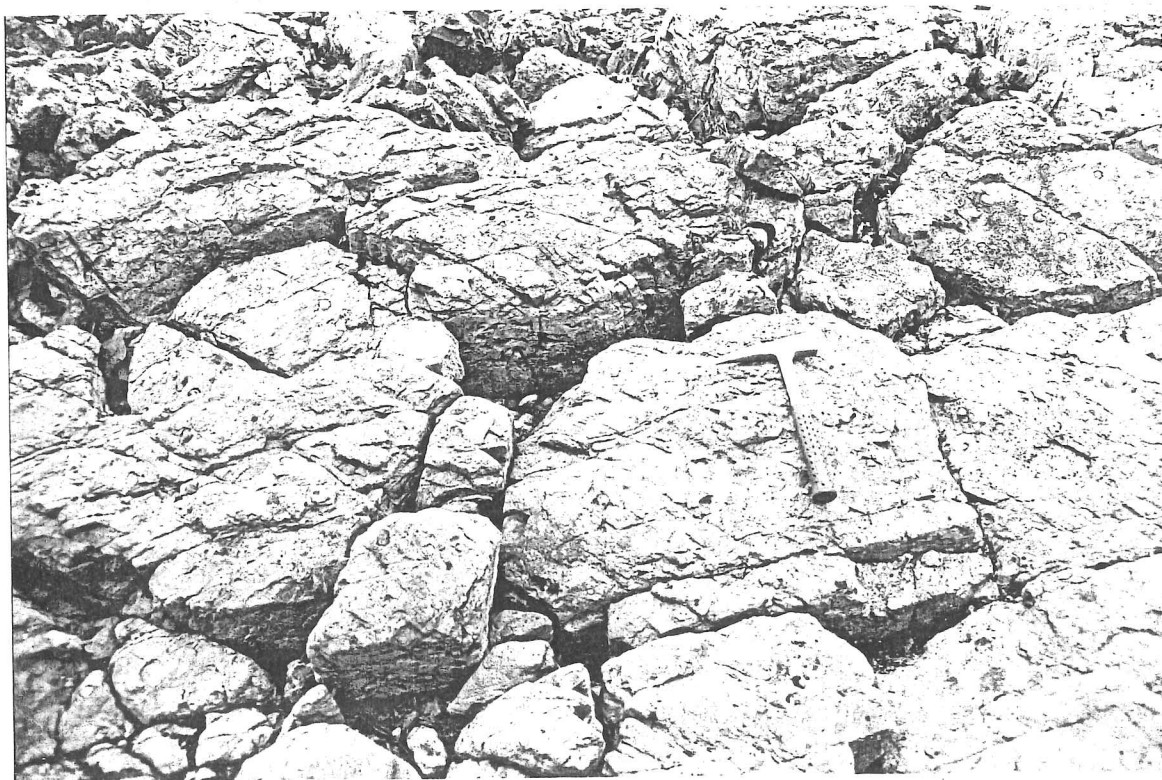
The West side of Gronfjord has high land (~600m topography on average) running N-S through the centre which is cut by rivers and glaciers and has a few km of flat plane by each coast. Glacial erosion has exposed cross-sections of these mountains and large scale folds with axes striking $\sim 340^\circ$ could be clearly seen. This general structure was also noticed in the beds West of Stemmevatnet which shallowed in dip from $\sim 20^\circ\text{E}$ to $\sim 10^\circ\text{E}$ over a few 100m. The published map shows a number of large thrust faults parallel to the bedding running through the area at a similar orientation to the fold axes. The scale of our study made these large faults difficult to identify as the beds were often disrupted by faulting on a smaller scale.

Along the coastal section and the gully to the South of the river the most obvious form of deformation was small scale (1-10m order) parasitic folding. Cross-sections of these areas show larger ~500m scale folds within units. Stereonet analysis of the parasitic folds suggest axes trending NW-SE ($\sim 300\text{--}320^\circ$) and plunging shallowly to the NE if at all. These were observed mainly in the Helvetiafjellet Formation, Kapp Toscana Group and the Vardebukta Formation. These units were also disrupted by mainly thrust faults of a few cm to m scale which were most easily seen in the more consolidated units. These typically dipped $\sim 40^\circ\text{W}$ also striking $\sim 320^\circ$. This seemed to suggest that the small scale deformation occurred along the same orientations as the larger scale faults affecting the whole area. The two main faults enveloping the area are oblique to one another and meet to the North East of the river sections between Vardebreen and Voringbreen. We wondered if the orientation of small scale faults would change systematically depending on position within this envelope but no clear pattern emerged, possibly due to the difficulty in measuring true orientation of enough of the faults exposed only in two dimensions.

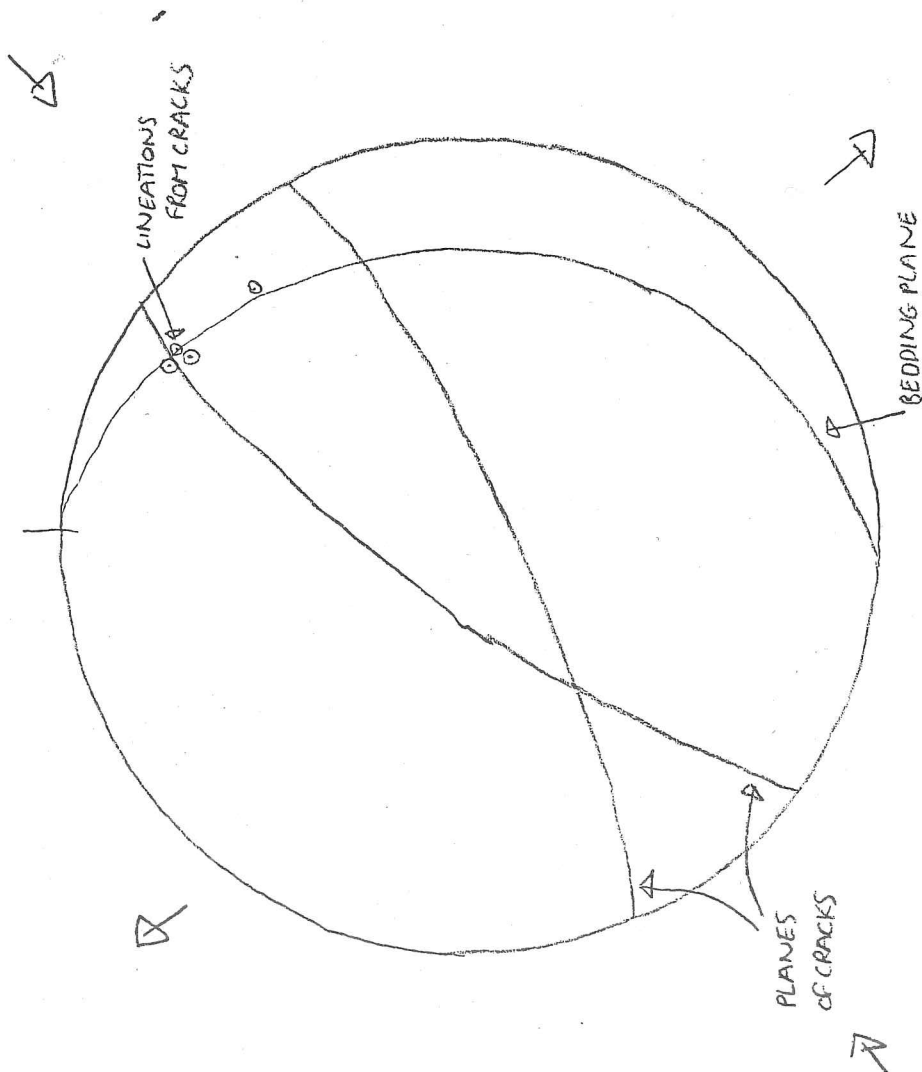
To the West of Stemmevatnet the well consolidated Gipsdalen Formation showed little of this fold and thrust deformation although it was here that the evidence of large scale folding was most clearly seen. The consolidation of these units allowed the preservation of cm scale en-echelon cracks on many surfaces. Kimura et al. also noted a progression in style of small scale deformation across the section at Festningen with folds to the east and cracks to the West which they interpreted as a result of depth during deformation. Where the cracks created measurable planes we found them to be steeply dipping and striking in groups of either $\sim 210^\circ$ or $\sim 230^\circ$. We considered this to be evidence of $\sim 220^\circ$ compression or $\sim 140^\circ$ tension. 220° compression fits best with the NW-SE trend of the horizontal structures so again the small scale features echo the overall trend of the deformation.

Along the coast to the North of the river, about halfway to Festningen we observed a few occurrences of normal faults showing displacements of up to a metre. These were exposed in a section facing E and each occurrence had a number of smaller cm – 10cm thrust faults within a few m to the North. These could probably accommodate some, if not all of the extension and so we concluded that they were a minor product of the main thrusting from forces orientated NE-SW.

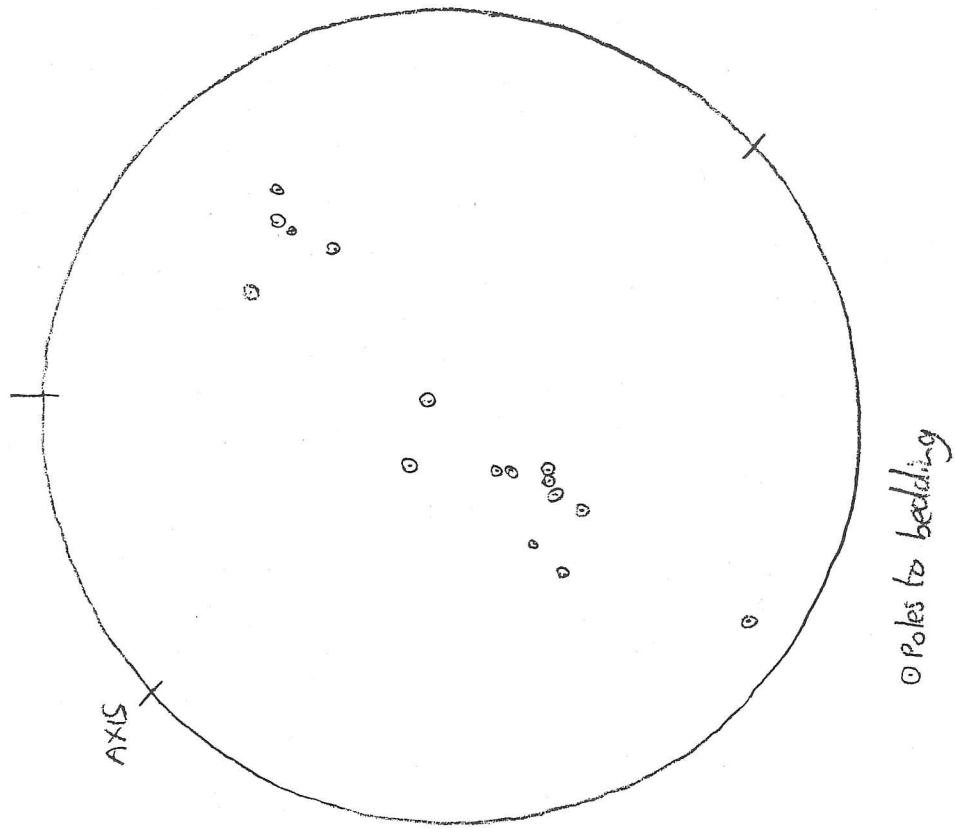
Small scale tectonic features, en echelon cracks on a bedding plane in the Gipsdalen Formation.



LOCALITY 2S

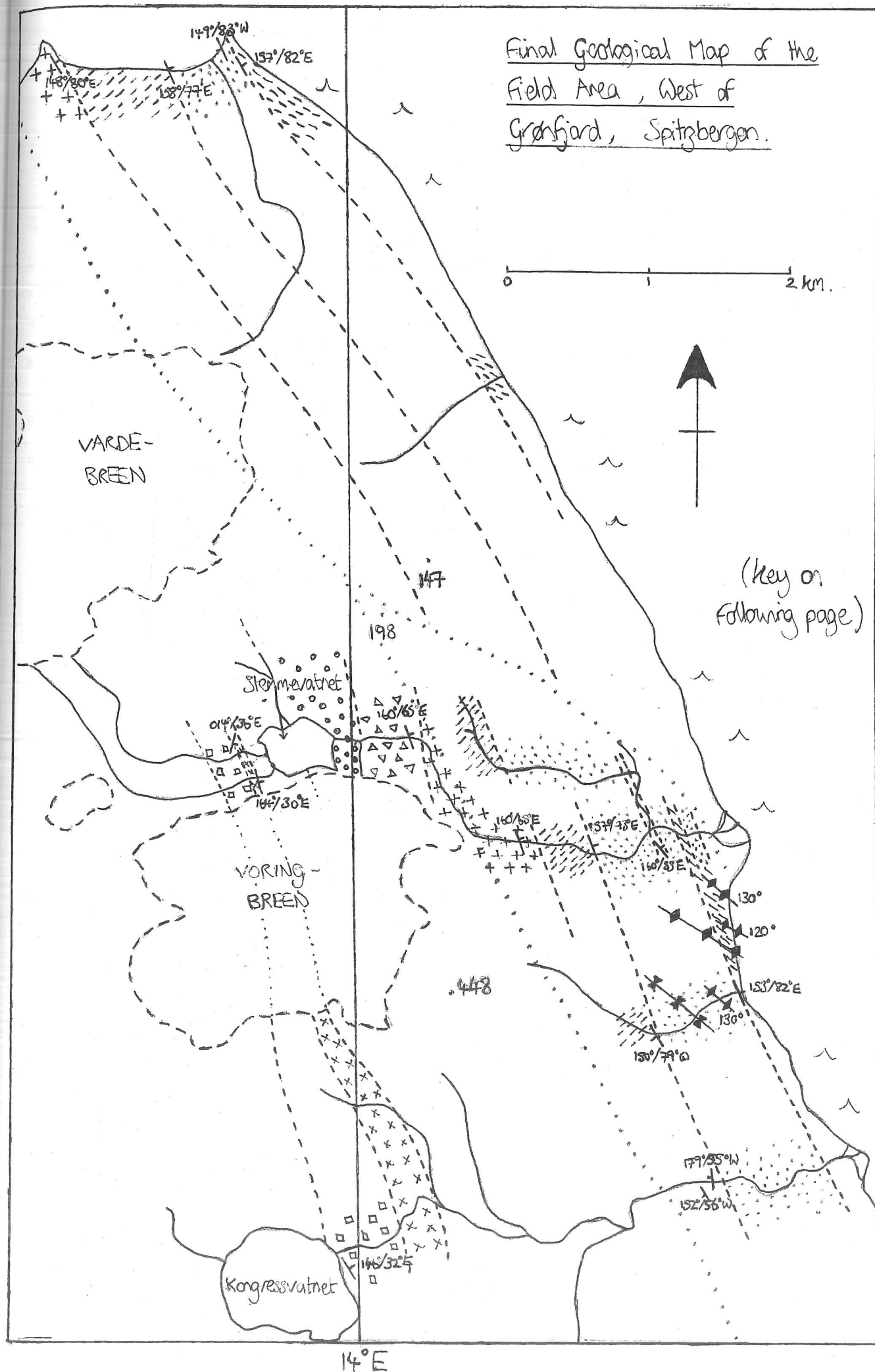


PARASITIC FOLDS ALONG SHORE



The other small scale structural feature that we encountered and could not adequately explain was in a few localities where the direction of dip for the steeply dipping beds along the river section to be opposite for otherwise traceable beds with the same strike on opposite sides of the river. This pattern would continue for 10's of metres and then by one side gently steepening the two sections would be coherent again. At most the difference in dip was around 20° . After excluding the idea of a fault along the river (due to the regions that did behave as expected) we thought that this was either evidence for an earlier period of deformation at a different orientation or a suggestion that deformation on the small scale is much less uniform than we had thought.

Final Geological Map of the
Field Area, West of
Grønfjord, Spitzbergen.



Key to the Geological Map

Lithologies



Quartz & Patches - Gipsdalen Formation



Heartrock - Kapp Starostin Formation.



Vardbukta Formation



Trillingorden Formation



Bravaisberget Formation



De Geerdalen Formation



Jamstfjellet Formation



Helvetiafjellet Formation.

Geological Symbols



Published Fault.



Contact.



Antiform



Synform



125°/40°SE

Strike and Dip.

Non-Geological Symbols



River



Ice and Moraine

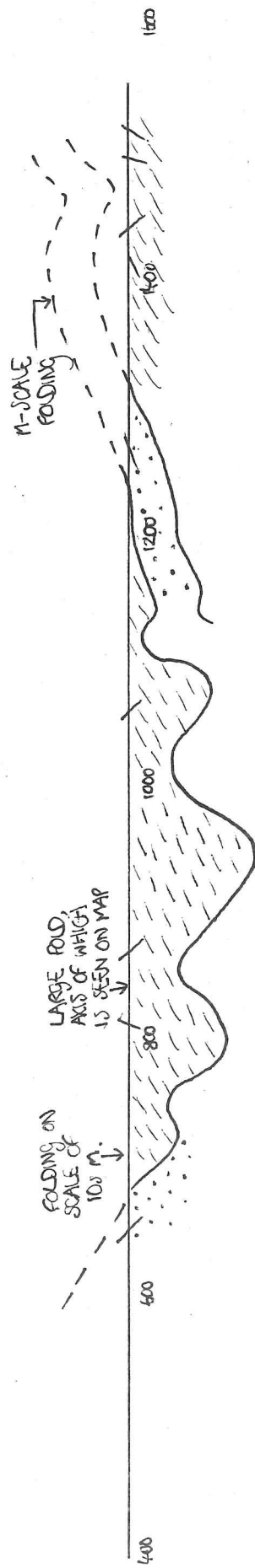


Coast

• 198

Spot Height, in metres.

Cross-section, NE/SW, Using Coastal Exposure.

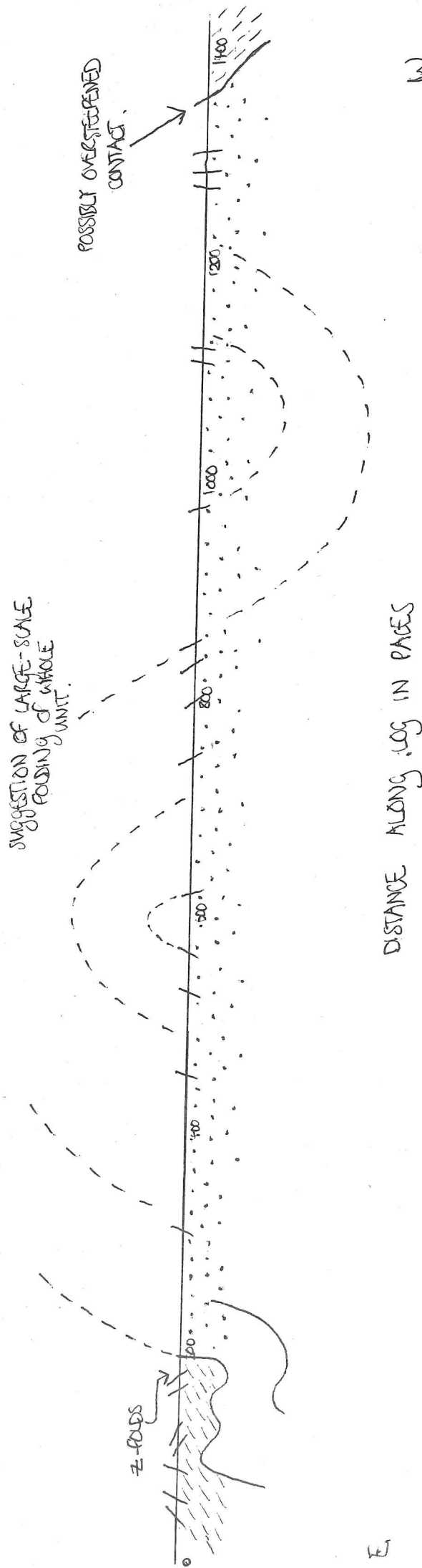


KEY

⋯⋯⋯ Kapp Toscana Formation

//// Helvetiafjellet Formation

Cross-section from Log of Gully, North of Kongressdalen



KEY

Helvetiafjellet Formation

Kapp Toscana Formation

Vardebakka Formation

Conclusion

Our aims for this project were to map the small scale structures of the area to the West of Gronfjord to consider the relationships between the orientations of different scale structures and the driving forces of the tectonics of the area, and to see if deformation on this scale is governed more by external tectonic regime or heterogeneities in the rocks.

The regional structures of the West Spitzbergen Orogeny trend NW-NNW as can be seen by the large scale folding in the area. We have identified some smaller scale folds within structural units and from the axes of their parasitic folds determined that these too trend in the same way. No significant patterns relating the orientations of minor faults to the large faults enveloping them could be distinguished although the general trend was again NW strike. En echelon cracks in the West of the area indicated compression from the NE, or tension trending SE. Despite a few minor extensional structures to the North of the area the tectonic regime recorded in this region is compressive.

Our study has shown that the small scale structures in this region give a good indication of the large scale tectonics that affect the area and that this signal is not lost due to sedimentary or other fabrics in the rock.

We also wanted to assess our own environmental impact on the landscape during the expedition. We hope that we minimised this and it was interesting to experiment with different methods of waste disposal to know what is appropriate in this environment.

The cultural experiences we had were an unexpected bonus and it was fascinating (and fun) to see life at Stemmevatnet and in Barentsburg, and the comparison between the Russian and Norwegian settlements. We met a diverse range of people, almost all of whom were exceptionally good to us and even our run ins with the wildlife ended well.

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