INTRODUCTION

Each summer since 1957, expeditions from Victoria University have joined in scientific activities organised within the New Zealand Antarctic Research Programme. Victoria's research groups, called VUWAE's for short, have been concerned with specific geological interests in areas within 150 kms radius of Scott Base, the headquarters of the New Zealand programme. Ready access and ease of travel have enabled staff and students to explore and map many of the valley systems of the McMurdo Oasis, the Koettlitz Glacier area and sites adjacent to McMurdo Sound.

The preliminary investigations, in the 1950's, were concerned with viewing a vast new continent which had remained scientifically 'untouched', but now Victoria's task has become one of tackling specific problems which have remained unsolved from the previous reconnaissance work. The 1969-70 Victoria expedition was concerned with Quaternary studies in (a) the McMurdo Oasis, (b) on White Island, and (c) at ice-free capes around Ross Island.

The party proved to be a well balanced group with interests in most geological fields. The ease with which each individual carried out research to fit the diverse and interesting subjects found made the expedition for each of us a pleasant and rewarding experience.

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PROPOSED SCIENTIFIC PROGRAMME

For the 1969-70 expedition, Neall proposed an investigation of a Recent marine deposit at Cape Barne, Ross Island. Previously, Professor A.T. Wilson (formerly of Chemistry Department, V.U.W.) and Dr. C.H. Hendy (Institute of Nuclear Sciences, D.S.I.R.) discovered the deposit during geochemical research in the 1967-68 summer field season. They found a number of well-preserved shell layers exposed beside the frozen lakes behind Cape Barne, at 30 m altitude above sea level. On identifying the molluscan and bryozoan fragments it became apparent that living shells similar to the discovered fossils have only been trawled from waters deeper than 63 metres. This clearly reflected the mode of formation of the deposit was not that of a near shore littoral environment as was previously thought. Furthermore, in Antarctica ice movement erodes most hard shelled living organisms from the shore-line environment. A deeper mode of formation was suggested for the deposit, similar to areas now found on the sea bottom of McMurdo Sound. The uplift of the deposit to this height was attributed to isostatic uplift. Radioactive carbon 14 dating of the shells revealed an age between 32,000 and 37,000 years old (Hendy, Neall and Wilson, 1969).

Because Hendy and Wilson collected only the largest shells visible for chemical analysis, a proposal was made by Neall to investigate the shell layer stratigraphy and the fossil content of these beds in detail. A full investigation of such deposits around the shores of McMurdo Sound might assist in establishing that a number of fossiliferous so-called 'raised beaches' may in fact be raised marine sediments. The proposal was approved in March 1969, and Neall and Kyle travelled to Cape Barne in collaboration with the Waikato University Expedition, who were studying the geochemistry of Deep Lake at Cape Barne.

After this, Neall and Kyle proposed to investigate the geology of Cape Crozier, at the easternmost tip of Ross Island (an area only previously visited briefly by two geologists, Dr. L. Harrington and Dr. S. Treves (see Treves 1967)). In an unpublished account, Dr. Harrington recognised a sequence of moraines, volcanic craters and eruptive rock types at Crozier, which he considered warranted 'a summer's field work'. As the area was readily accessible to a Victoria University geological party, it was proposed to investigate the geology of the coastal section at the Cape, in particular searching for marine deposits and also collecting rock samples for petrological and geochemical work.

A report of shell layers from Cape Bird, together with a request by the Waikato Expedition to visit this locality, prompted the combined party to include a call there. The group was then scheduled to return to Scott Base by December 5th.

Neall and Kyle then parted with the Waikato Expedition members and planned to join Vucetich and Topping at the Labyrinth, in the Upper Wright Valley. The Labyrinth is an unusual area of very steep gullies with flat treads between, which form a box-canyon type topography. The mode of origin of the area is a controversial issue; Cotton (1966) considers it to have formed under the influence of glacial action, whilst Smith (1965) thought it was formed by a catastrophic flood.

Whilst Neall and Kyle were visiting Ross Island, Vucetich and Topping planned to investigate large areas of the Wright Valley to try to elucidate the history of the most famous of the Dry Valleys. Quaternary geology focuses attention on glaciations and on superficial deposits which are glacial in origin, or which are linked with periglacial environments. These deposits commonly include soils or paleosols (fossil soils), and are consequently studied by pedologists. In the Dry Valleys, glacial deposits are poorly exposed, so glacial geologists and pedologists study the same deposits, unfortunately using a different terminology. They rarely study together and much confusion exists over terms used in expressing erosional and depositional processes. There is even much conjecture between various workers as to the validity of Antarctic glaciations and their correlatives elsewhere in the world. Vucetich and Topping had as their main objectives:

(a) Mapping of glacial and associated deposits, together with a study of their soil character and their weathering in the Wright Valley. VUWAE 10 (1965-66) initiated this study near Lake Vanda and reported dry frozen tills which are easy to expose by digging. (Most soils in Antarctica are rather shallow because a few inches beneath the surface is a permafrost layer of hard ice, which is as hard as concrete). The aim of this study was to try and link the sequence of glacial deposits, the past lake levels of Lake Vanda, some radiometrically dated basalts and some fossil pecten shells near Bull Pass. This work involves much levelling for height control and the investigators proposed to use Lake Vanda Station as their camp site.

(b) A limited study of the Labyrinth together with Neall and Kyle.

(c) To describe and sample critical sections in the Lower Taylor Valley where VUWAE's 12 and 13 had nominated stratigraphic columns of glacial and fluvioglacial sediments. Correlation of selected members with Cape Bernacchi marine benches was also to be attempted.

From the Labyrinth, the 4 man party was scheduled to camp in the Lower Taylor Valley, to describe in detail one of the best sections of Pleistocene sediments in Antarctica yet discovered. Due to an unusual succession of events, a stream draining the Commonwealth Glacier has eroded into the sediments as it drains to the sea, exposing a number of cliffs, which we intended to describe.

The party was then scheduled to return to Scott Base on 29th December, with Vucetich and Topping returning to New Zealand on the next available flight. Neall and Kyle then planned to travel over sea and shelf ice to White Island, camping in a wannagan (a hut on skis). There, fossil deposits, glacial cut benches and volcanic rock samples were to be studied and Neall and Kyle expected to return to New Zealand on 16th January, 1970.

EXPEDITION MEMBERS

The 1969/70 party (VUWAE 14) was composed of two staff and two students as follows:-

Expedition Field Leader:	Vince Neall, B.Sc. (Hons.), Junior Lecturer
Expedition Scientific Leader:	Colin Vucetich, B. Ag. Sci., Reader in Pedology
Geologist:	Wayne Topping, B.Sc. (Hons.), Doctoral Student
Geologist:	Phil Kyle, B.Sc. Student.

The overall structure of VUWAE 14 was planned during March 1969, and applications were received from about 20 personnel for the two vacancies of geologists to accompany Neall and Vucetich. Messrs. Kyle and Topping were selected at an interview in May 1969, and Neall, Kyle and Topping attended the Antarctic Training Week at

Waiouru, from 15th to 22nd August. This year's training week provided an excellent opportunity to meet a somewhat large number of field and base personnel who were selected for the season's activities, and it also provided useful training in climbing and skiing for the newcomers to Antarctica.

PREPARATIONS

The expedition was financed by a grant from the University Grants Committee, under the administration of Professor R.H. Clark. Routine items purchased included non-returnable clothing, food, and stationery, and travel costs to and from Christchurch. Insurance of personnel and instruments was ably handled by Mr. John Andrews, Science Faculty Clerk, who also assisted in the purchase of some items of equipment. All instruments used in Antarctica on this expedition were Geology Department property, except one barometer obtained from Antarctic Division, D.S.I.R.

Field Gear. Many of the necessary items for field work in Antarctica already belong to the University, and these include sleeping bags, windproof clothing, and certain kitchen utensils. However, a number of necessary items which the University does not possess were obtained from Antarctic Division. This equipment consisted of two polar tents, two 557 radios, one first aid box, marker flags to attach to bamboo poles, and kerosene for the Primuses. Small personal first aid kits were purchased, but the D.S.I.R. first aid boxes contain the restricted drugs and dressings necessary in an emergency. Three University Commanda radios taken with us in case of emergency proved invaluable. Already proclaimed by a number of radio experts as useless, on a number of occasions they were used to relay messages when the 557's were non-operational, and in one instance one was used to relay to McMurdo the whereabouts of a crash-landed helicopter in the Wright Valley.

Kitchen gear purchased included two pressure cookers in addition to the usual kitchen supplies. Pressure cookers are a standard item of D.S.I.R. kitchen boxes and it was felt an addition of these two items to the VUWAE supplies is an investment for future expeditions as they enable a complete meal to be cooked on one Primus in a matter of 15 minutes.

Two new special survival sheets were taken into the field in case of emergency.

Food. Almost all the food consumed this summer was left from the previous year's expedition supplemented with some fresh and tinned meat, and tinned fruit. Only five food boxes were purchased from the D.S.I.R. supplies. Considering the cost of these food-boxes, and the present supplies of VUWAE food stored at Scott Base, the University should be able to supplement our present food reserves for next year's expedition with a much lower expenditure compared to purchasing D.S.I.R. food.

FIELD PROGRAMME

On arrival at Scott Base we were asked to combine our programme with that proposed by the University of Waikato, so the itinerary for two members was changed slightly to include Cape Bird before Cape Crozier. Neall and Kyle travelled up to Cape Barne with the four members of the Waikato Expedition in a Nodwell, driven by Rae Tatham, Deputy Leader at Scott Base. This means of transport enabled Kyle on the journey to collect rock samples for geochemical analysis from the Cape Evans area. After a week at Cape Barne, during which time Neall and Kyle travelled as far north as Cape Royds, they were transported by Navy helicopter to Cape Bird. Two members of the Waikato team, Wilson and Hendy, were also taken there by helicopter. The party was only delayed one day at Cape Bird and then was transported back to McMurdo and on to Cape Crozier, where an extensive mapping programme along the coast enabled the geologists to complete a geological map of the area. The survey extends from the Discovery II Pole (which is of historical significance, for it was here that a message was left on the 'Discovery' Expedition in 1901-03 for the relief ship 'Morning') southwards for six miles to Igloo Spur. Here Wilson, Bowers and Cherry-Garrard built a stone igloo during the winter night of 1912 in attempting to obtain the famous Emperor Penguin eggs. The 1969-70 parties were a few days' late leaving Cape Crozier and arrived back at Scott Base by helicopter on December 8th.

Meanwhile Vucetich and Topping departed from Scott Base on 17th November for a camp site 1 km east of the large loop moraine in the Lower Wright Valley. On the 18th November whilst they were away working, a helicopter crashed in the hills nearby and caught fire, regrettably with the loss of two lives. Their camp was used in the emergency (whilst they were away) and the surviving co-pilot took one of their down jackets (later returned) and headed for the Miserve Glacier camp to give the "Mayday" call. The survivors who wore wind-proof clothing were only burnt on their hands and faces, the clothing

apparently being non-inflammable. We do suggest, therefore, that for any future air travel in Antarctica, windproof clothing and gloves be worn.

On 26th November, a helicopter carried Vucetich's and Topping's gear to Lake Vanda whilst they walked the 15 kms distance. Due to unfavourable weather and problems in helicopter transport, the programme was then modified and their Labyrinth visit was reduced from a proposed 8 days to one day. The decision to operate from a main camp near Vanda Station proved wise because of the very tangible support from the Vanda Leader and his staff in untangling some complicated logistics whilst camped at Vanda and later in the Lower Taylor Valley.

After replenishing supplies at Scott Base, Neall and Kyle set out by helicopter on 11th December for the Labyrinth, intending to meet Vucetich and Topping there. Due to an unfortunate series of circumstances, the helicopter failed to bring the latter party to the Labyrinth and Neall and Kyle spent six days there without a radio or first aid kit, awaiting their comrades to arrive. Apparently the helicopters were grounded over this period and eventually Vucetich and Topping walked to the Labyrinth. The following day a helicopter arrived to take our party of four to the Lower Taylor Valley, but because it was already carrying a number of passengers, the pilot found he was unable to take our load (which under normal circumstances would have constituted an easy weight to transport). After instructing us to dump kerosene and food, the pilot was still unable to take the load, so a hasty decision was made to leave Kyle and Topping with a tent and food (but little kerosene). This enabled Neall and Vucetich to carry on with work in the Lower Taylor Valley if the other members of the party were delayed. On travelling around to the Lower Taylor Valley, the helicopter landed at Lake Vanda to pick up Vucetich's radio and scientific equipment required over the next few days. Meanwhile another helicopter in the region which was diverted to the Labyrinth to pick up Kyle and Topping, developed engine trouble and crash landed in the Labyrinth. On arrival of Neall and Vucetich at the Lower Taylor Valley, we witnessed a Hercules flying over that area and heard Topping relaying the position of the grounded helicopter, by University Commanda radio, to Lake Vanda who passed the message to Scott Base and thence to McMurdo. In turn all the crew were rescued uninjured, and a day later Kyle and Topping walked to Lake Vanda. Their actions during this time are worthy of commendation.

Helicopter support was again not forthcoming and Kyle and Topping

waited for a week at Vanda before eventually meeting up on 27th December with Neall and Vucetich in the Lower Taylor Valley. Meanwhile Neall and Vucetich achieved the scientific work which they had scheduled and at 3.30 p.m. on New Year's Eve the party was airlifted back to Scott Base by three helicopters (one Navy and two Coastguard). All three had been relaying stores to Vanda, thus collecting us on their way home.

It was not possible for the expedition to take a wannagan to White Island, so we were given use of one of the Scott Base snow-tracs. Topping remained at base to accompany us to White Island when Vucetich returned to New Zealand on 2nd January, 1970. This constituted a safer (3-man) party to travel across the shelf ice. We headed for the centre of the island so as to avoid the large crevasses at the northernmost point, and then travelled along the coastline to the rock outcrops we wished to visit. We returned to Scott Base on 9th January, 1970, and during the remaining five days at Scott Base collected rock samples along Hut Point Peninsula, and packed our crates of equipment for return to New Zealand.

Medically, the party was very fit and although one member suffered from dehydration on one occasion whilst another tipped some boiling water on his foot, no serious accidents were sustained.

ITINERARY

Nov. 11	Neall, Kyle, Vucetich and Topping depart Wellington by ferry for Lyttleton 2130 hrs.
Nov. 12	Party at Wigram, awaiting departure south
Nov. 13) Nov. 14) Nov. 15)	Party at Wigram, awaiting departure south - aircraft delayed
Nov. 16	Neall and Vucetich depart 0400 hrs. by Starlifter to Williams Field. Kyle and Topping depart 0700 hrs. by another Starlifter. Arrive at Scott Base a.m.
Nov. 17	Party at Scott Base preparing equipment and food prior to departure into the field

Nov. 18	Neall and Kyle depart 1300 hrs. with Waikato party by Nodwell to Cape Barne. Vucetich and Topping depart for Lower Wright Valley by helicopter.

ITINERARY OF NEALL AND KYLE (19th November - 17th December)

Nov. 19) Nov. 20)	Geological work at Cape Barne
Nov. 21	Blizzard - lie-up day
Nov. 22	Cape Barne, detailed geological work
Nov. 23	Day trip to Cape Royds by foot, returning via fossil deposits at 200 ft. contour
Nov. 24	Cape Barne - measuring beach ridges
Nov. 25	Neall and Kyle transported by helicopter to Cape Bird
Nov. 26	Cape Bird - examination of fossil deposits
Nov. 27) Nov. 28)	Cape Bird - measuring beach levels
Nov. 29	Cape Bird - excursion to Shell Glacier and Trachyte Hill
Nov. 30	Awaiting transportation to Cape Crozier. Transport delayed.
Dec. 1	Neall and Kyle to Cape Crozier p.m. by helicopter
Dec. 2	Cape Crozier - geology around Post Office Hill
Dec. 3	Cape Crozier - geology of Igloo Spur and The Knoll
Dec. 4) Dec. 5)	Cape Crozier - geology adjacent to Northern Adelie Penguin Rookery
Dec. 6) Dec. 7)	Cape Crozier - awaiting helicopter to arrive for return to Scott Base
Dec. 8	Neall and Kyle return to Scott Base

Dec. 9) Dec. 10)	Neall and Kyle at Scott Base rearranging equipment and rations
Dec. 11	Neall and Kyle arrive Labyrinth 1930 hrs.
Dec. 12) Dec. 13) Dec. 14) Dec. 15) Dec. 16)	In Labyrinth, awaiting arrival of Vucetich and Topping Visits to sites within short distance of campsite No helicopter - grounded for five days
Dec. 17	Vucetich and Topping arrive at Labyrinth to join Neall and Kyle

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ITINERARY OF VUCETICH AND TOPPING (17th November - 19th December)

Nov. 17	Scott Base to Lower Taylor by helicopter
Nov. 18) Nov. 19) Nov. 20) Nov. 21) Nov. 22) Nov. 23) Nov. 24) Nov. 25)	Geology in Lower Taylor Valley - emphasis on till lithology and weathering character etc.
Nov. 26	Lower Wright to Vanda on foot, gear carried by helicopter
Nov. 27	Geology near Vanda
Nov. 28) Nov. 29) Nov. 30)	Digging and describing tills near Bull Pass
Dec. 1	Day off
Dec. 2) Dec. 3) Dec. 4) Dec. 5)	Completed sampling and levelling in Bull Pass area

Dec. 6)
Dec. 7) Completed sampling and levelling in Bull Pass area
Dec. 8)
Dec. 9)

Dec. 10 Waiting helicopter for Labyrinth all day

Dec. 11 " " until 1215 radio sched.)
)
Dec. 12 " " " " " ") local
) geology
Dec. 13 " " " " " ")

Dec. 14 No helicopter flying - bad weather; studied local bench levels

Dec. 15 " " " " " ; sampling algae

Dec. 16 " " " " " ; photo interpretation

Dec. 17 Walk to Labyrinth

ITINERARY OF COMBINED PARTY

Dec. 18 Neall and Vucetich travel to Lower Taylor Valley. Kyle and Topping remain in Labyrinth

Dec. 19 Neall and Vucetich working in Lower Taylor Valley at New Harbour. Kyle and Topping camped in Labyrinth

Dec. 20 Kyle and Topping walk down to Lake Vanda station
Neall and Vucetich in Lower Taylor Valley

Dec. 21)
Dec. 22)
Dec. 23) Kyle and Topping awaiting helicopter transport from Lake
Dec. 24) Vanda
Dec. 25) Neall and Vucetich in Lower Taylor Valley
Dec. 26)

Dec. 27 Kyle and Topping arrive by helicopter in Lower Taylor Valley to join Neall and Vucetich

Dec. 28) Dec. 29) Dec. 30)	In Lower Taylor Valley completing geological work and awaiting transport back to Scott Base
Dec. 31	Neall, Kyle, Vucetich and Topping return to Scott Base at 1530 hrs. by Navy and Coastguard helicopters
Jan. 1	Party at Scott Base
Jan. 2	Vucetich returned to New Zealand
Jan. 3	Neall, Kyle and Topping remain at Scott Base. Vucetich arrives back in Wellington
Jan. 4	Neall, Kyle and Topping set out by Snow-trac 2100 hrs. for White Island
Jan. 5) Jan. 6) Jan. 7) Jan. 8)	White Island - geology from northwestern rock outcrops up to summit of Mt. Heine
Jan. 9	Party returned to Scott Base at 2300 hrs.
Jan. 10	Geology of Castlerock and northernmost outcrops of Hut Point Peninsula
Jan. 11) Jan. 12) Jan. 13)	Neall, Kyle and Topping packing equipment and rock samples for return to New Zealand. Gear to be forwarded on H.M.N.Z.S. Endeavour
Jan. 14	Neall, Kyle and Topping depart by Super Constellation 2200 hrs.
Jan. 15	Party arrives back in New Zealand. Kyle and Topping arrive in Wellington
Jan. 19	Neall arrives back in Wellington after brief stay in Christchurch

Record of Time Spent in Field

Neall and Kyle spent 61 days in Antarctica. Breakdown of this figure into the division of time spent in various pursuits is as follows:-

Days spent at Scott Base (this includes 2 geology days there)		13	
Days spent on geology		23)	
with travel		9)	48 days in the
Lie-up days		16)	field
	Total	61	

An additional 10 days were spent in transport between Wellington and Antarctica. Of the 16 lie-up days in the field, most were due to delayed helicopters failing to arrive rather than poor weather conditions. Only 2 or 3 of these days were lost through high winds. Of the 48 days spent in the field, almost 50% were spent on geological pursuits, which is a particularly high percentage considering the delays experienced. Although there were many problems with the helicopter support this summer, we consider ourselves most fortunate that we were able to pursue all the activities we had planned. (The Waikato party was less fortunate).

Vucetich and Topping spent 44 days in the field together. These have been subdivided as follows:-

Fully productive	...	26
Fragmented days	...	13
Lie-up days	...	5
	Total	44

Their intended programme did not fully allow for unpredictable circumstances and was not completed. However, the main objectives in the Wright and Taylor Valleys were achieved.

An estimated 12½ hours of helicopter flying time can be considered granted to the Victoria party. This is ½ hour more than requested, and was due to the arrival on one occasion of three helicopters when we had advised only two were required.

FIELD NOTES AND RECOMMENDATIONS

1. The purchase of survival sheets for individual parties is suggested for future trips. Recently made available on the New Zealand market, they may prove to be useful some day in the future.

2. The servicing of the 3 University old type Commanda radios by Jenkins Electronics in Karori proved to be an amazing success. Besides being used during one emergency, there were times when the American scientists at Cape Crozier could not contact McMurdo with their ultra modern radios and generators. Following their failure we used our Commanda and were able to call Scott Base with perfect reception. They should again be checked by Jenkins Electronics and taken by future VUWAE's.

3. Field personnel should wear their windproof non-inflammable clothing and gloves whilst travelling in U.S. Navy helicopters.

4. The VUWAE instep crampons again proved most useful on the flat ice-covered lakes.

5. A can of fluorescent coloured paint sprayed on boulders forming a triangle indicatesquickly a suitable landing site for the helicopter pilots, who appreciate this signal. Also, helicopter time can be saved if on landing at a camp site a flare is obtained from the loadmaster. When the pick-up helicopter is sighted, releasing the flare enables the pilot to locate your position much more quickly and easily and saves the helicopter having to circle to assess the wind direction.

6. We strongly urge next year's party to supplement the food already in the VUWAE store with food to their own liking. The purchase of D.S.I.R. food boxes is not only expensive but also an uninteresting and unbalanced diet. A complete list of food remaining at Scott Base has been compiled separately. Two VUWAE food boxes were left in the Lower Taylor Valley and about 6 food boxes from this and last year's VUWAE's are located at Vanda Station.

7. Mechanical trouble with the existing helicopters caused a considerable amount of delay in our proposed timetables. In no way does this reflect upon the able support given to us by the VX-6 helicopter pilots, or to the Leader and staff at Scott Base who gave us the maximum amount of assistance possible within their capabilities.

8. All of the windproof trousers have completed their usefulness. A new set of at least four pairs will be required for any future expedition. Furthermore, one ice-axe shaft was broken, which should be repaired.

9. During the summer season various members of the party met and observed women working in Antarctica, as part of the USARP and NZARP programmes for 1969-70. There seem no problems in allowing women in Antarctica, provided they accompany persons who have previous experience in this region. To put an inexperienced all female party in the field seems venturesome since few all male parties carry out field work without prior Antarctic experience.

10. At all times alternative transport to helicopter flying hours is strongly recommended. Wheeled machines could be relatively easily used in the Dry Valleys, as is the case at Vanda Station.

SCIENTIFIC REPORT (Neall and Kyle) - by V. E. Neall

(a) Cape Barne

The ice-free area adjacent to this Cape is situated 33 kms NNW of Scott Base. Cape Barne forms a right angle in the coastline. Along the southern side are three partially dissected basalt cones, the most westerly exposed to the interior where two dykes and associated agglomerates have resisted marine erosion to form the Cape Barne Pillar. To the north, kenyte lavas have flowed westwards from sources high on Mt. Erebus. During Pleistocene times ice is considered to have cut two parallel arcuate valleys, concave to the west, within the kenytes, each about 100 ft. deep. These valleys now possess three lakes, and adjacent to them are steep cliffs which display a complex of polygonal joints radiating outwards from the centres of the kenyte lava flows. To the east, most of the bedrock outcrops are mantled with moraine, forming a hummocky topography with many distinctive debris cones.

Within the inner eastern valley a small pass of moraine separates two of the lakes. It is at this site, within and upon the surface of the moraine, that the fossils have been located. Consisting of three beds, alongside a prominent mirabilite deposit, the fossils consist mostly of molluscs, bryozoans, sponge spicules and foraminifera.

The kenyte forms an undulating topography with bedrock cropping out on the higher levels to form small tors which display well developed polygonal jointing. Within the hollows coarse sands have accumulated which are considered to represent the end product of salt weathering out the individual crystals within the bedrock to form 'lag gravels'. A thin morainic cover may be located in a few places which often contains diagnostic pale green kenyte erratics.

The moraine to the east extends northwards to form the coastline of Backdoor Bay and southwards to the Barne Glacier. Kenyte erratics are to be found on the basalt cones to the south, whilst two moraine mounds a little to the north are composed almost entirely of basalt with a few granite erratics. On steeper slopes only the coarse angular blocks remain as a scree, the fines presumably winnowed away by the wind. In contrast, the gentle lower slopes form more typical morainic lithologies of unsorted, chaotic masses of blocks, sands and silts which frequently form solifluction deposits.

Marine sands and gravels have accumulated at the seaward ends of the outer, western coastal valley. Here four raised beaches were levelled for height and distance from sea level.

The basalt cones to the south have been denuded to expose central dykes and breccias with interdigitating steeply dipping lava flows. A curved fault plane was discovered within the eastern cone, which is considered to represent a fault of similar structure to a cone-sheet dyke. Considerable controversy surrounds the age relationships between the basalts and kenytes. Smith (1954) draws no conclusions, whilst Treves (1962) considered the basalts were older. Our field observations were not conclusive, but there is a strong suggestion that kenyte overlies basalt at one locality. Between the two eastern basalt cones is a low saddle with an outcrop of kenyte bedrock, which we consider must be younger than the basalt. Furthermore, no basalt scoria or lavas were found upon the kenyte lavas.

Thus from our work the geological history of Cape Barne could be summarised into the following series of events:

(a) Eruption of basalt cones;

(b) Outpouring from flanks of Erebus of kenyte lava flows (at least three successive flows are visible near Cape

Royds.

(c) The cutting of the two arcuate valleys by an enlarged ice sheet, which occupied McMurdo Sound, with erosion of the seaward portions of the basalt cones.

(d) The deposition of moraines over extensive areas of land behind the cape, less than 32,000 years ago.

(e) The deposition of beach gravels and sands at both ends of the seaward valley prior to the postglacial rise in sea level. This is assumed because the present lake within the valley is beneath present day sea level, and there is no indication of a former, larger lake which has decreased in size to its present form.

Detailed petrological and geochemical examination of the rock types is proceeding at present, together with identification of fossil molluscs and bryozoans collected from within the inner valley, and also at two localities within moraine along the coast of Backdoor Bay.

(b) Cape Bird

The excursion to Cape Bird (40 kms north of Cape Barne) proved more rewarding than expected. A number of fossils have been recorded here previously by Speden (1962). Belonging to the Scallop Hill Formation, they are presumed to belong to at least the Penultimate Interglacial, and have since been uplifted to at least 600 m above sea level. They are now found within moraines being deposited by the Mt. Bird ice cap. A search throughout this area revealed many of the fragmented pectens (Chlamys andersoni) and bryozoans collected previously, together with the rarer solitary coral Gardineria antarctica and a whale bone about six inches long.

Traversing along the coastline to Cape Bird B, twenty-three successively raised beaches were discovered, and considerable time was spent in measuring these features along a number of parallel traverse lines. The formation of the beaches on this spit is considered to have formed by a current flowing around Cape Bird from the east, eroding and carrying material along the coast (probably by longshore drift) until it reaches the principal northward current of McMurdo

Sound. Here the gravels have been deposited and under favourable weather conditions the moving ice flows express the surface currents exceedingly well.

The highest of the sequential raised beaches was only about 6.9 m above sea level, but raised beaches found at other localities along the coast range up to 11.4 m a.s.l.. A bench found between 36 m and 39 m a.s.l. is attributed as being of Last Interglacial age.

A one day excursion was made to the more southerly region of the ice-free area at Cape Bird. Here a number of quite different volcanic rock types are exposed (Cole and Ewart 1968), and a collection was made for detailed geochemical work. Rock types include hornblende-pyroxene trachytes, olivine basalts and olivine-augite basalts. Additional features observed and described along the coastline include gravels being deposited by the ice-foot (the rim of ice along the shoreline). Samples have been obtained (in conjunction with the Waikato and Canterbury Expeditions) of soils developed on variously aged, raised beaches from the Northern Penguin Rookery to compare the effects of addition of guano to the regolith.

Dr. C. Hendy is intending to radiometrically date a number of the beaches (assuming that the penguins are rapid colonisers of ice-free areas as soon as they become available). If this dating is successful, it will enable us to determine the build-up of concentrations of major elements at the sites with respect to time. This may form an interesting chronosequence with few variables involved in the system. Such opportunities are rare.

(c) Cape Crozier

Little geological field work has been attempted at Cape Crozier, and since 1957 the area seems to have assumed a 'biological playground' function with the large number of penguins nearby. The cape is located on the most easterly extremity of Ross Island and is about 70 kms northeast of Scott Base.

Only one fossil - a gastropod, has previously been found at Cape Crozier, but a search in the area did not reveal any further fossils. An outcrop of tuffaceous sandstone was discovered adjacent to Post Office Hill, samples of which will be submitted to the recognised experts for microfaunal and microfloral analysis. Three

raised beaches were also measured at the Northern Penguin Rookery to the north and south of Williamson's Rock.

The rest of our time was spent on the volcanic geology of the coastal section at Crozier. The area mapped was a 9 km strip of land, about 6 km wide, which extended up to an altitude of about 600 m a.s.l., but not including the 150 metre high cliffs which fringe the sea. This mapping was possible because a base-sheet existed of this area, prepared by Lands and Survey Department, Wellington.

A stratigraphic sequence of eruptive events has been constructed as follows:

Pyroxene basalt (youngest)
Hornblende, plagioclase, trachyte
Basalt
Olivine basalt
Older basalts of the Mt. Terror cone

The two principal cones in this region are The Knoll and Post Office Hill, both composed of trachyte. In both cases a small crater is preserved at their summits, and The Knoll crater contains a frozen lake. Basalt has been erupted from The Knoll as a late phase of activity, forming thin black flows over the steep-sided, light yellow trachyte. On a nearby basalt cone spirally twisted volcanic bombs were located. Further to the north another basalt cone is exposed to show a trachyte dyke. From this type of evidence the age sequence was established. Detailed examination of these interesting and important rock sequences will proceed shortly when the specimens arrive back in New Zealand.

Many more basalt and trachyte cones extend eastwards along the flanks of Mt. Terror, almost to the summit. These cones remain unmapped, but a request has been made to U.S. Geological Survey, Washington, to obtain aerial photographs of this region.

A great variety of lichens were found at Cape Crozier, including red, yellow and green crustose types and a black and green fruiticose lichen.

At this point it should be noted that the detailed examination of the volcanics was limited to Ross Island. Here the Tertiary and Quaternary volcanic rocks constitute the McMurdo Volcanic Group,

a suite of rocks quite different from those occurring in the North Island of New Zealand. Whereas the North Island andesites and rhyolites belong to the calc-alkaline suite of volcanics more typical of orogenic areas, the alkaline suite of the McMurdo Volcanics is more typical of continental volcanic areas.

Ross Island consists of the central basalt - kenyte cone of Mt. Erebus (3,794 m) which is symmetrically surrounded by three volcanic lineations characterised by a basalt - trachyte - basalt sequence of eruptions . These three lineations consist of the Mt. Bird (1,766 m) eruptive centre to the NNE; the easterly lineation of Mts. Terra Nova (2,130 m) and Terror (3,230 m) to Cape Crozier; and to the SSE, the Hut Point Peninsula lineation. Samples collected by Scott's expeditions (Smith 1954) showed the basalts of the Erebus vent to be different from the surrounding linear vents. The dissimilarity of Mt. Erebus from the eruptive centres of Cape Bird, Cape Crozier, and the Hut Point areas offers an interesting problem requiring detailed geochemical and petrological investigation of samples collected. This study is planned for this year's laboratory research work.

(d) The Labyrinth and the Lower Taylor Valley

Both the above localities are in the Dry Valley Region, some 150 kms NW of Scott Base. The surfaces at the western end of the Wright Valley are all structurally controlled by the inter-bedded Beacon sandstones and Ferrar Dolerites where a broad platform of dolerite is exposed called the Labyrinth. This particular 'bench' of dolerite has been eroded to form a system of steep walled canyons which anastomose within the dolerite lithology only. Conjecture as to the processes forming it have been many and varied. Our limited investigations there (due to support problems) suggest the Labyrinth was first exposed by glacial action by a previously expanded Upper Wright Glacier. During this cutting many of the accordant cirques to the north and south probably formed. Later development of the box canyons seems to be predominantly an 'in place' erosional process whereby the dolerites are broken down into their individual components. Small potholing within dolerite pebbles in the Labyrinth clearly display how the wind erodes the coarser crystals from the dolerite.

Whilst at the Labyrinth our ideas on the geological history of the region were formulated with respect to data from the Taylor

Valley (about 85 kms from Scott Base). Recent American literature shows that volcanics were erupted 2.7 million years ago in an ancestral Taylor Valley (Armstrong, Hamilton & Denton 1968). This clearly indicates that pre-Pleistocene glaciations existed, and we therefore collected the highest basalt and kenyte erratics we could find in the Lower Taylor Valley. Dating of these volcanics could assist in interpreting whether events in the Lower Taylor match those in the Middle Taylor Valley. Such an assumption was made by early reconnaissance workers, but has yet to be validated. A potassium-argon (K/Ar) date of these samples would give a maximum date to these deposits. (See page 22).

Together with Vucetich and Topping, the Pleistocene sediments in the Lower Taylor Valley were sampled to see if there are any marine microfossils present within these sediments. Microfaunal examination may support the hypothesis that these sediments were deposited in a fiord, and that they have since been uplifted above sea level. Alternatively, they may have formed in a huge lake. Microfaunal analyses are to be completed by Dr. P.N. Webb (N.Z. Geological Survey) on foraminifera, Mr. W. Briggs (Geology Department, V.U.W.) on ostracodes, and Neall on bryozoans.

The type locality of the Taylor Formation (Speden 1962) was also examined. The distribution of the deposit has been extended, our investigations showing that shells are in situ up to 9 metres above sea level. They are located at most points along the coastline of the mouth of the Taylor Valley. In all cases they are marine deposits on moraine, and they are not found in areas subjected to flooding or the build-up of deltas. A detailed map of these localities will be published later. Shells found in these deposits include Adamussium colbecki, two other genera of bivalves, an as yet unidentified gastropod, and two complete echinoderms. An age determination for these shells may assist in determining the rate of uplift of this section of the coastline.

(e) White Island

White Island (25 kms south of Scott Base) is mostly aproned by glacial moraine. Fragments of the pecten Chlamys andersoni, and worm tubes were located at the northernmost point, as found by Speden (1962). Undoubtedly the same fossils as the Scallop Hill Formation, they range up to 54 m a.s.l.

The most conspicuous features on White Island are five

glacial benches on the north side of the island. These were measured in altitude using a barometer and are at approximately 114 m, 177 m, 246 m, 300 m and 340 m above sea level. None of these features could be correlated with distinctive moraines reported from Black Island by Veila (1969). No diagnostic kenyte or Tertiary fossiliferous erratics were sighted. It can only be suggested that the Black Island benches were cut by an expanded Koettlitz Glacier, whilst White Island has been subjected to the Ross Ice Shelf.

A few volcanic rock samples were collected from the north facing cliffs and from the summit of Mt. Heine for further detailed work.

White Island would appear to consist of at least two coalescing basalt shield type volcanoes which have been eroded by cirque development at a period of lower sea level. The two vents lie along a north-south line, with the northern vent represented by a large oval crater on the northwestern side of the island. The later history is dominated by the building of many small basalt cones with their remnant craters scattered over most areas of the island. From the general topographic appearance and the lack of trachyte eruptions, it is considered that the island is the last phase of the basalt - trachyte - basalt sequence noted by Cole and Ewart (1968) on Black Island and Brown Peninsula (both of which lie within 30 km to the west of the island). White Island is probably considerably younger in age than either of the latter two areas.

(f) Hut Point Peninsula

Two days were spent investigating rock outcrops to the north of Scott Base. Cole and Ewart (1968) completed a survey of the geology of Cape Bird, Black Island and Brown Peninsula, and to complete this work along the west side of McMurdo Sound we examined the geology of Castlerock and the outcrops to the north, along the central portion of Hut Point Peninsula. Wellman (1964) has previously studied the surficial geology of the area. Castlerock is composed of a complex autoclastic palagonite breccia, which is presumed to have formed in the throat of a volcano, and it has later been intruded by a small dyke. Most of the other cones were basaltic, with some craters displaying fine examples of once molten volcanic bombs. A new outcrop of trachyte was located, and a breccia similar to that composing Castlerock was found to the south

behind McMurdo. The famous sponge spicule balls were still located in this region (Wellman 1963). It is hoped that this sampling of volcanic rocks together with those from Capes Barne, Royds, and Crozier, and White Island can be combined to complete the regional reconnaissance of the volcanics.

(g) Potassium - Argon (K/A) Dating

It may be possible for a small number of volcanic samples collected by VUWAE 14 to be submitted for K/A dating. The following samples are considered well worthwhile being dated for the following reasons:

(1) Kenyte from the highest moraines in the Lower Taylor Valley - Dating of this sample could give a maximum age to some of the glacial events in the Lower Taylor Valley.

(2) Basalt from Cape Barne - This would give some indication of age relationships between the basalts and kenytes, as well as giving information about erosional processes. The kenyte is being dated for paleomagnetic work in the United States.

(3) Basalt from White Island - This sample dates the oldest rock in the stratigraphic sequence recognised at the northern end of White Island. It gives a maximum age to cirque development as well as to the regional volcanic stratigraphy.

(4) Trachyte dyke from basalt cone at Cape Crozier.

(5) Basalt cone intruded by above dyke - Clearly, when such a well exposed relationship is established between two contrasting rock types, it is imperative to investigate their relative ages. These two samples represent a pattern observed at a number of localities at Cape Crozier, and they are considered to be representative of the area. An indication of the general stratigraphic sequence may assist in correlations to volcanic events studied by Cole and Ewart (1968).

(6) Basalt dyke from Castle Rock, Hut Point Peninsula -

From topographical evidence this rock may well be the oldest feature of the area. Composed principally of autoclastic breccias, a small dyke has intruded these rock types, thus dating the last phases of activity preserved at this locality. Again, dating would assist assessments of the rates of erosion in the region.

(7) Basalt from Cape Bird - This sample was selected because it dates the main cone-building phase of Mt. Bird. Comparison with samples from Cape Crozier, Hut Point Peninsula and Black Island will give comparative data on the build-up of these volcanic lineations and assist in comparisons with the sequence of Cole and Ewart (1968).

Another three samples are to be submitted by Dr. J.W. Cole from those collected by VUWAE 9 on Black Island (see Cole and Ewart, 1968).

It is hoped that all these samples will be dated at the Institute of Nuclear Sciences, Gracefield. Material will be submitted for whole rock analyses except the kenyte which will be determined on the extracted anorthoclase phenocrysts.

(h) Recommendations for future scientific projects

1. As a follow-up to our investigations a tentative programme is suggested for VUWAE 16 for 1971-72. This is to examine the volcanics exposed above 2,000 ft altitude at Cape Crozier, when photographs will then be available from U.S. Geological Survey. A visit to the Upper Koettlitz Glacier region could also be incorporated into this expedition to search for kenyte outcrops presumed to exist on Mts. Morning and Discovery. The source of the kenyte in moraines in the Lower Taylor Valley and at Black Island is presumed to have come from the Koettlitz region, but now some confirmation is required of this assumption by the early geologists. Examination of rock types on the flanks of Mt. Discovery could also be encompassed on this expedition, enabling a petrologist to carry out the first detailed sampling of this area. Collection of these samples could prove a valuable contribution in the understanding of the geochemistry of the McMurdo Volcanics and may also reveal some extremely important outcrops of kenyte. It is this type of "specific problem" research which is required in the future to solve the more

difficult and less glamorous questions which have been left unresolved by earlier workers.

2. In conjunction with geophysical research on the sea and shelf ice, an interesting study could be made by a Victoria student of the sediments which now mantle the sea floor of McMurdo Sound. Geophysicists are continually probing through the ice and collecting sediment samples for experimentation; biologists are continually dredging the bottom to collect invertebrates and divers scan the bottom waters examining seal behaviour etc. It seems about time that a sedimentologist collate the wealth of unusual information available to prepare a sediment map of the Sound.

SCIENTIFIC RESULTS (Vucetich and Topping) - by C. G. Vucetich

(a) Wright Valley

The Wright Valley continues to attract summer field parties after 14 years of exploration. A glacial origin has been proposed for the valley and deposits representing four glaciations have been recognised at varying heights. The basin occupied by Lake Vanda is assumed to be of glacial origin and it is this area which has received most attention for it now occupies the lowest and perhaps driest part of the valley. Supplied mainly by melt water from the Lower Wright Glacier, the Onyx Stream water flows 18 miles into Lake Vanda.

The glacial and allied deposits together with their acquired characteristics have not attracted serious attention. They are scanty and generally lack the status of "moraines". In a period of 30 days in the Wright Valley, the unconsolidated deposits were examined from the Lower Wright Glacier to the Labyrinth. Provisional results indicate:-

1. 'Ancestral' Lake Vanda dates from the stranding of a shallow arm of the sea in excess of one million years ago. Two layers of well preserved fossil pectens (Turner 1967) within boulder sands occur 1.0 and 1.5 metres below two poorly defined benches near Bull Pass. Additional benches formed within corresponding tills to those at Bull Pass are well preserved westwards towards

Lake Vanda.

2. The higher Lake Vanda bench levels record:

(a) a maximum level marked by incomplete erosion of glacial tills at approximately 72 m above the Vanda datum level;

(b) a 3 m lower level, on bedrock, also marked by thin weakly iron-stained sands;

(c) a level 6 m lower, on bedrock or marked by almost fresh sands.

None of the lower benches can be differentiated as significant static periods.

3. The last down valley ice preceded the marine benching and the till sheet then deposited survived on the south side of the valley. A subsequent very limited advance into the North and South Forks predates bench level (b).

4. The Lower Wright Glacier has advanced westwards for 15 miles from the present day glacier front and the ice at the maximum advance was 200 ft thick at a point 6 miles along the valley from the eastern end. The advances post-date the marine episode and a lack of lacustrine and fine tills in the valley is taken to indicate the presence of limited barrier ice in the past.

5. No significant sources of Lake Vanda water, other than the Lower Wright Glacier, have been demonstrated. The bench level (a) is related to a short-lived maximal flow of meltwater following retreat of the glacial advance. Bench levels (b) and (c) may mark the retreat stages of later advances. A generalised water balance will be calculated on the assumption that there have been relatively small changes in the Lake Vanda environment. The available evidence on the ground indicates that this environment has been continually arid during this period.

6. The above interpretations provide negative evidence of the four glaciations initially defined in the Wright Valley. It does provide a time scale which permits the dominant weathering processes to be rationalised - notably the complete disintegration and wind dispersal of glacial deposits, weathering of the exposed basement rocks around Lake Vanda, and deepening of the valley floor around Lake Vanda.

(b) Note on Vanda Station

Vanda Station established near Lake Vanda in 1969 is particularly well sited for hydrologic and environmental studies in a polar desert region. Our appreciation of this environment is so limited and biased by experience in other latitudes that the present day processes acting on and within the basement rocks and the "soils" remain largely unknown. The Vanda 3-year programme is costly to operate, is beset with many logistic problems and requires a hand picked staff. The staff must have the full backing and continued support of the people who have proposed or initiated projects which they want continued. What is not sufficiently appreciated, particularly at a distance of 2,000 odd miles, is that the local Vanda experimental conditions change and equipment may need to be modified. At the Vanda end any such thing as "splendid isolation" is completely fictitious.

(c) Lower Taylor Valley

VUWAE's 12 and 13 have designated glacial tills in this region, and they have attempted to identify a depositional sequence. Following a brief VUWAE 14 visit some anomalies have been explained.

(i) Tills of the New Harbour Formation, 200+ metres thick, pass upwards to drop-pebble beds evidently deposited from floating ice. The tills are considered to have been deposited within a fiord when glacier ice occupied the Taylor Valley to a height of 300-400 metres above the valley floor.

(ii) Subsequently, the ancestral Lake Fryxell formed behind the barrier of New Harbour Formation and a sequence of sheet tills was deposited, firstly lacustrine sediments, followed by coarse tills.

(iii) The volcanic erratics assist in a limited evaluation of time control. The 2.7 million year old olivine basalts erupted in the middle Taylor Valley (Denton and Armstrong 1968) almost certainly comprise some of the erratics up to 600 m elevation above the valley floor down to the New Harbour and Fryxell Formations. Kenyte, not known to outcrop in the valley, is widely distributed in the Lower Valley and the erratics were deposited after 2.7 million years and after the last advance of Taylor Glacier. Volcanic erratics have been sampled both in the Wright and Taylor Valleys for petrologic study.

(iv) In view of the as yet little evaluated eustatic-isostatic marine control at New Harbour, events cannot be related to sea level control. However, the New Harbour Formation is clearly not a moraine and the sediments deposited from floating ice have subsequently been uplifted and tilted (approximately 5^{o} SW). New Harbour sediments are involved in the isostatic rebound well recorded in the McMurdo Sound region, and they are apparently very old (from evidence of subsequent till weathering and the deposition of the younger Fryxell Formation).

(d) Collection of Samples

Samples of volcanic erratics, tills, "soil layers" and basement rocks were collected mainly from the Wright Valley. The tills are as yet poorly defined and are not known to be marine. Their mineralogy and chemistry will be the major laboratory study.

A sequence of algae samples has been collected from 10 surveyed bench levels above the north shore of Lake Vanda. A case for C^{14} dating will be made.

(e) Conclusions

A substantial break-through in correlating glacial events awaits further geochronology. For the volcanics, kenytes remain undated and selected basalt erratics could be dated. Carbonates within old lacustrine sediments and Lake Vanda water samples (plus Onyx Stream water) could be examined using established methods.

Food List of Stores at Scott Base

The following list has been compiled of all food remaining at Scott Base at 14th January, 1970. This should assist future expeditions to prepare balanced rations:

Tinned meat (to be served hot)	10 tins
Tinned meat (to be served cold)	20 tins
Tinned fish	4 tins
Meat bars (four flavours)	65 bars
Freeze-dried meat	138 packets
Marmite (4 oz.)	11 jars
Tinned jam (14 oz.)	6 tins
Dehydrated vegetables (carrots, peas and beans)	58 packets
Mixed soups	45 packets
Sledge biscuits	33 packets
Chocolate (nut milk and dairy milk	7 lbs.
Salt	4 lbs.
Dehydrated onions	3 large packets
Dehydrated mashed potatoes	6 large packets
Egg powder	11 packets + 2 tins
Milk powder	12 packets (about $1\frac{1}{2}$ lbs.) + 8 lbs. in tins
Dehydrated apples (6 oz.)	9 packets
Sugar	30 lbs.

Little or no dehydrated potatoes, milk, meat, meat bars, sugar, marmite, onions, trail biscuits, coffee, candles or soap should be required for the next 4-man expedition. A detailed list of items will be forwarded to the next VUWAE leader. The following items do not keep in Antarctica and have not been stored - new rations will be required:

Bacon, butter, segment cheeses, assorted spreads etc. for lunches, tinned fruit, fresh steaks and tinned meat; also additional supplies of chocolate.

In additon to food supplies, there are 3 dozen candles and $2\frac{1}{2}$ dozen bamboo flagged poles in the VUWAE store.

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