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CAMBRIDGE ECUADORIAN ANDES EXPEDITION

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Patrons

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ABSTRACT

The team of six left the UK for nine weeks during August and September 1985 to carry out several investigations into scientifically interesting aspects of the glacial and post-glacial environment near the volcano El Altar in the Equadorian Andes.

Attempted ascents of some of Ecuador's major peaks were also to be made. The expedition members were:-

David Hendicott	-	Expedition Leader
Judith Aston	-	Spanish Interpreter
Nigel Bunn	-	Equipment Officer
Martin Holley	-	Treasurer, Photographer
Martha Liley	-	Botanical Project Leader
Alison Smith	-	Medical Officer

All are presently undergraduates at Cambridge University.

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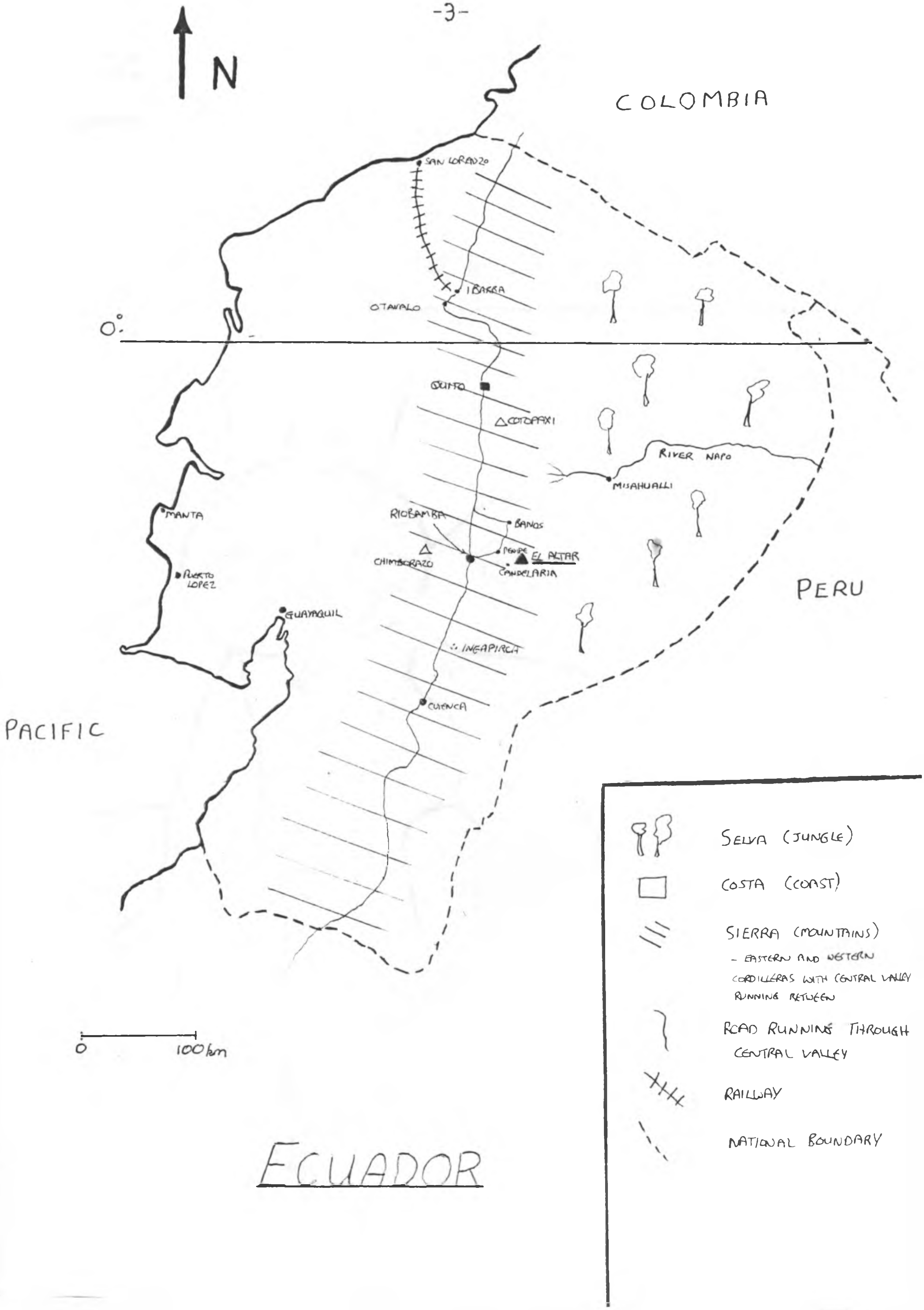
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- EASTERN AND WESTERN CORDILLERAS WITH CENTRAL VALLEY RUNNING BETWEEN
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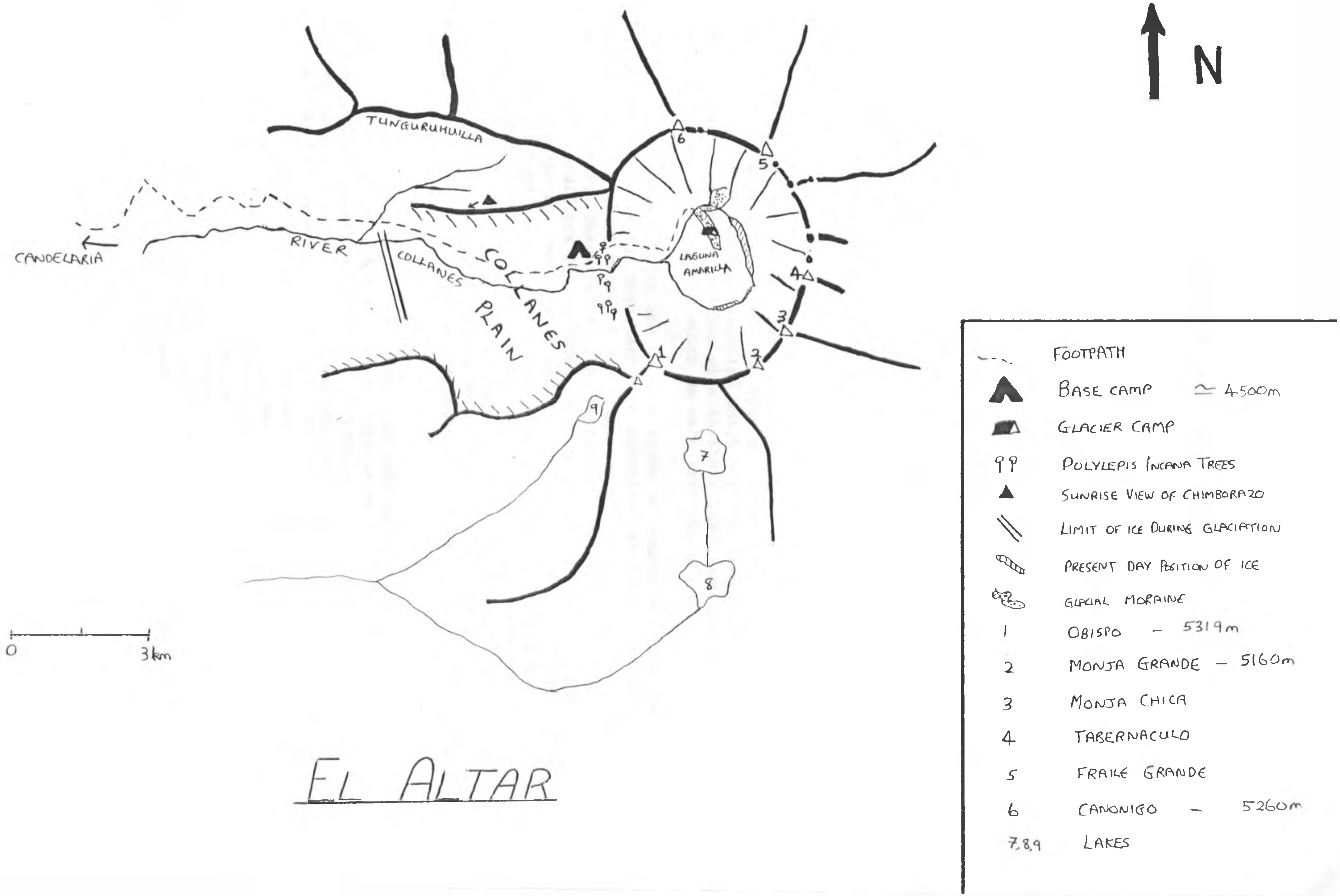
RAILWAY
NATIONAL BOUNDARY

ECUADOR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FOOTPATH
BASE CAMP ≃ 4500m
GLACIER CAMP
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EL ALTAR

GENERAL REPORT - ECUADOR 1985

Plans for this expedition began at least a year in advance of our arrival in Ecuador. Inspired by the beauty of highland scenery whilst camping on a glacier in the Alps during the previous Summer, Dave, Nigel and Martin resolved to reach new heights and visit the Andes, with the aim of carrying out a scientific study on an equatorial glacier. Ecuador seemed a natural choice, having a suitable field area whilst being one of the more politically stable countries in South America.

On return to University for the Autumn term, logistical planning for the expedition steamed ahead. The team was expanded from three to six in number, contacts were established and projects to be undertaken were determined. The next major hurdle was fundraising. Approval by the Cambridge Expeditions Committee gave us a charitable status, and recognition from the Royal Geographical Society was a major boost. We managed to raise sufficient funds and the expedition was able to take place.

On August 4th we arrived in the capital of Ecuador, Quito - 2850 metres up in the mountains. Quito offered a good opportunity for a few days acclimatisation before the big trek up to base camp. We broke ourselves in gently to the hardships which were to come, staying with the British Defence Attachee and his wife in their luxurious home. This became our base in Quito for which we were very grateful.

Two days in Quito and we were ready to embark upon the journey to the proposed site for base camp - an adventure in itself, which took the best part of three days. A bus trip down the 'Valley of Volcanoes' took us to Banos. Described as the 'Gateway to the Jungle', Banos is on the Eastern Cordillera of the Andes range at some 1800 metres above sea level, a popular spa resort with hot springs. We spent an afternoon here shopping for food, mostly in the local market. This gave us a good opportunity to brush up on those key Spanish phrases and practice our haggling skills. All very entertaining, although carrying the newly purchased provisions proved not to be so much fun! Treating ourselves to a meal out, we decided to leave the local delicacy of 'Cuy' (roast guinea pig) for our return.

We spent the night in Banos and woke up to a misty, drizzly day. Finding an idle truck driver to take us on the next stage of our journey caused one or two problems, particularly in view of the poor weather conditions. Our destination was the village/hamlet of Candelaria, high up in the mountains. The road from Banos to Penipe was fine, but it was the final 15 kilometres that caused great problems. The 'road' between Penipe and Candelaria was still under construction, it was more like a very muddy track, precariously cut into the edge of the mountains with a dizzy plunge down into the valley below should the brakes fail. The small Chevrolet type truck was obviously not built for such journeys and the total lack of grip on the tyres, along with a distinct absence of windscreen wipers did not help! After many a push start, the driver finally refused to go any further. Apologetic but insistent, he left us in the mud and rain to make our own way. It was at this stage that the altitude first began to hit us as we staggered the last few kilometres with our burdensome equipment.

Our arrival in Candelaria certainly caused a stir. As we stood in the main square which doubled up as a highly muddy football pitch, a crowd of inquisitive school children came running up to us. We had unwittingly disrupted an end of term examination in the village school!

After a game of football and some heavy haggling, we finally managed to make an agreement for three mules to take our equipment up to the glacier on the following day. There was absolutely no way that we could have carried it all ourselves! The people of Candelaria looked upon us with disbelief when we announced our intentions to spend over three weeks at El Altar - 'hace mucho frio' they warned us of the cold, harsh conditions up there, but by now we were prepared for anything - Well, almost anything. Attempting to keep up with the muleteers proved impossible as they shot off into the distance early the following morning. Five hours later, six shattered explorers staggered onto the high paramo at the head of the Collanes Valley. Ahead of us lay the steep rock sill leading to our final destination - the glacier - although we could not actually see this wonderful site we had all read about. The surrounding peaks were totally obscured and we saw nothing as the mules disappeared into the mist. It was just us and the mountains.

Tents pitched, the sky cleared and we were captivated by our first view of El Altar. It was all worth it, just for that view. The Caldera - the result of a volcanic explosion thousands of years ago - was obscured by the foreboding rock still bearing ahead of us, but the jagged snow capped peaks of El Altar stood out dramatically against the skyline. We slept well that night, tired but content.

We soon moved camp to a better spot, closer to the Polylepis trees, and explored the immediate surrounding area to find the best spot for a glacial survey. A unanimous decision was made on the interior of the crater - there were no other accessible glaciers! The glacier in the crater has now retreated so far back that it is almost up against its steep back wall and a classical glacial corrie is being created.

A tent was pitched in the crater and the glacier project set up. We established a rota system whereby at any one time two people were working in the crater and two more on the Polylepis trees at base camp. This allowed time for the remaining couple to explore the surrounding area, for which maps are very poor.

The location was truly idyllic and none of us found ourselves at a loose end. The crater was an amazing place in which to camp, the tent itself being perched on the end of a moraine. The crater lake, Laguna Amarilla, is constantly growing in size as the glacier continues to recede. Lying in the tent at night, eerie echoes resonated around the crater as ice falling from overhanging seracs thundered down onto the glacier. The crater had its own unique atmosphere, hard to put into words.

The physical landscape of Ecuador consists of three main regions:- The coastal plain, the highlands of the Andes and the humid jungle. The mountain belt is divided into two volcanic ranges with a highland corridor of fertile land running between them from North to South. Hence the term 'Valley of the Volcanoes'. El Altar is on the Eastern Cordillera, where there is a very steep drop down from the mountains into the jungle. The Eastern Cordillera is the more mountainous of the two ranges, the Western having more imposing volcanoes which rise straight up from an almost flat plain. On clear mornings it was possible to see many of these volcanoes from peaks near El Altar. An Ecuadorian climber was recently killed in an attempt to climb the Obispo peak of El Altar from the inside, when he was hit by an ice fall. Needless to say, our mountaineering whilst at base camp was limited to the more accessible and less technically demanding surrounding peaks or ridges, from which some beautiful early morning views of distant volcanoes were afforded.

El Altar is surrounded by barren, wild paramo with little flora or fauna. Birdlife is the most prolific, ranging from tiny humming birds to the magnificent Condor. Two of us were lucky to encounter the rare Andean Wolf, although at the time its beauty was not fully appreciated due to the shock of seeing its silhouette at the tent door! It managed to chew our petrol container, puncture it, drain out the petrol and carry the empty plastic carton away down the valley during the night! It was fortunate that we had extra supplies of fuel.

The vegetation of the region is mostly strong tufts of grass and cactus type plants. The Polylepis trees stand out in being located on the lower slopes of the rock sill. Much of the Collanes Plain is poorly drained with marsh like vegetation. Annual rainfall is excessively high in the El Altar region. We pitched base camp at the foot of the rock sill on slightly higher ground, where the trees offered some protection against the wind and drainage was better.

After spending over three weeks at El Altar we were, perhaps, surprisingly reluctant to leave. Living under relatively primitive conditions proved to be no great hardship and certainly led us to rethink our values. We had become very attached to the barren beauty of the Collanes Plain and held a strong respect for the peaks of El Altar towering above. Sunset was always a pleasant time of day as we watched the changing light on the peaks of Altar, whilst eating yet another bowlful of rice and vegetables! No time to linger once the sun had gone down - in bed and with the light out by seven most nights before the cold really set in. One early morning a 2 a.m. start afforded us with a beautiful view of sunrise on Mount Chimborazo. It was a sight to be remembered and made us resolve to attempt an ascent of this volcano.

Thus, on route from base camp back to Quito we had no choice but to pay a visit to the climbers hut at Chimborazo. We reached this hut in style, battling across miles of barren volcanic wasteland in a taxi! It is amazing where Equadorian taxi drivers are prepared to take their passengers.

Unfortunately, two of our number fell ill and were unable to attempt the ascent, whilst another's crampons broke en route. However, the remaining three reached the summit after a midnight start and a twelve hour climb. Sunrise from the slopes of Chimborazo was breathtaking, with the shadow of the volcano reflected in the clouds.

Leaving Chimborazo we discovered the joys of hitching, a highly enjoyable form of travel which we subsequently resorted to many times. Herded onto the back of an open trailer with a group of 'merry' Ecuadorians, we sampled the local fire water - 'Agua Diente' - made from maize or fermented sugar cane, which is strong stuff and seems to be an intrinsic part of Ecuadorian culture. It's 'medicinal' qualities are dubious but sampling it was a fun way to mix with the Ecuadorians, despite the after effects!

We were left with two and a half weeks to visit other parts of Ecuador - the coast, Inca ruins, the jungle and the famous Otavalen market. This gave us a more general feel of the diversity of Ecuador's land and people.

Ingapirca is the site of an ancient fortress dating back to the Inca empire which reached Ecuador in the fifteenth century and disbanded soon after. Traditional Andean rural life continues undisturbed in this region and the Indians dress very colourfully.

Whilst in the jungle, we indulged in a two day trek into virgin forest. This entailed sleeping rough, shooting the rapids in dugout canoes, crossing rivers on precarious bamboo bridges and trudging through the undergrowth. We started from Misahualli - a frontier village on one of the major tributaries to the Amazon - The River Napo. Indians bring their produce in to Misahualli by dug out canoe twice a week. From piglets to bananas, this produce is then transported by lorry to the larger towns.

We travelled from Ibarra to San Lorenzo on what might qualify for one of the world's greatest train journeys. We passed through spectacular scenery, a long journey, but worth every minute. The train itself consisted of a bus on rails rather than wheels! The track is single and almost overgrown in places. It was fortunate that we only derailed once and on a relatively safe stretch of line. It was very amusing to see a train being bump started! The guard pours sand down a chute onto the rails to give extra grip when the diesel run train is struggling to climb up the mountainside. At every station the usual hoard of street hawkers piled onto the so-called train, causing total chaos, but a lot of fun. From San Lorenzo we hitched a ride onto a nearby island by canoe. Sunset over the Pacific that evening was unforgettable. Even on a tiny Pacific island, the western influence was evident and we found ourselves boogying to Michael Jackson, with a sea of inquisitive onlookers peeping at us. The population in this Northern coastal region of Ecuador is largely negroid. Rumour has it that they escaped the slave trade in North America and settled on the Ecuadorian coast. The atmosphere was totally different from that of the rest of Ecuador. Another example of Western influence was the way we kept stumbling across pool tables in the most unlikely places - on tiny Pacific islands and in the heart of the jungle. How they were transported to these regions remains a mystery to us.

The Otavalen market provided excellent opportunities for present buying and sampling local delicacies along with exotic fruits. The Otavalens are world renowned for their weaving craftsmanship. The whole town sprang into action from the early hours of the morning. An experience not to be missed.

The festival we stumbled across in Ibarra was fun and we danced the salsa until the early hours of the morning, joining in with the festive spirit.

Our two months sped by and we were soon back on the plane home. It was a highly successful expedition and an opportunity of a lifetime. Throughout this report we hope to give an accurate account of our experiences and achievements. Not being cheated or robbed once, we found Ecuadorians very hospitable and accommodating and are grateful for the opportunity that our sponsors helped to give us.

Obispo - El Altar

Riobamba Market

The Crater - El Altar

Chimborazo at Dawn

Base Camp - El Altar

Typical Andean Home - Candelaria

Sangay Erupting

Looking Back at Obispo

SCIENTIFIC OBJECTIVES

A THERMAL BALANCE STUDY OF THE CALDERA GLACIER, EL ALTAR

AIM

The Caldera glacier is undergoing an extended period of rapid mass loss primarily due to melting. The study aimed to measure the magnitude of incoming and outgoing energy fluxes to the glacier surface, therefore identifying the major contributory factors to the rapid mass loss. It has been suggested that, because of El Altar's proximity to the rain forest to the East, which results in warm humid air currents and high levels of precipitation, the situation is unlike that of glaciers at high latitudes where absorbed solar radiation is often far more important in net energy terms than latent heat provided by rainfall.

INTRODUCTION

The El Altar crater is approximately 2½km in diameter with the crater floor (4200m) surrounded on three sides by virtually sheer crater walls rising to majestic peaks at well over 5000m. The fourth side of the Caldera was blown out in an enormous eruption leaving an open crater rim to the West, providing the only access to the Caldera. The peaks are permanently snow covered and well glaciated with six glaciers situated on the El Altar group, two of these inside the Caldera. Descriptions from Edward Whymper as early as 1880 recorded the Caldera glacier snout hanging over the Western lip of the crater; subsequent records and photographs have shown a steady retreat until field work by Hastenrath (May 1978) showed the snout to protrude only several hundred metres along the crater floor, having undergone an estimated volume loss of $5 \times 10^7 m^3$ this century. Today the Caldera floor is filled with several sulphurous lakes into which the glacial meltwaters empty before shedding into the Collanes River.

The glacier could be divided roughly into three sections:

(i) An almost vertical hanging glacier on the inside face of the Eastern crater wall consisting of completely exposed ice.

(ii) An area near the bottom of the crater wall continually fed by falling ice seracs and small avalanches from above. This section extended some 300m along the crater floor before terminating in an ice cliff approximately 10m high at the edge of the easternmost lake.

(iii) Further small tongues extending either side of the easternmost lake further into the central area of the crater floor. These areas were out of range of avalanches or ice fall danger and were almost completely covered with moraine and dirt cones to depths of greater than 1.5m. This was the only safe area on which to set up camp in order to carry out the proposed three week thermal balance study.

METHOD

The energy fluxes and methods of measurement were as follows:-

(a) Net SW Radiation Input

Incident short wave solar radiation was measured at roughly 2½ hourly intervals throughout daylight hours (6 a.m. to 6 p.m. measurements beginning at 7 a.m.) using a solarimeter. The solarimeter gives a small voltage output proportional to the vertical component of incident solar power flux - this was easily measured using a millivoltmeter. The instrument was set up permanently on the moraine surface, being levelled by means of an integral spirit level bubble. Levelling was important when the incident light was direct (when the sun's disc was free of cloud) rather than diffuse. This gives total SW radiation incident on the glacier surface. However, of this total some is reflected - the ratio of reflected to incident fluxes is known as albedo and ranges from around 0.8 for fresh clean snow to less than 0.1 for a dark dirty irregular surface. Albedo was measured by taking measurements with the solarimeter inverted above the surface - such measurements are necessary far less frequently than incident radiation measurements since albedo is only surface dependent and the surface only changes significantly after snowfall or a snow covering melting.

(b) Precipitation

Since rain and snow fall at temperatures within only a few degrees of ambient temperatures (i.e. near freezing point) it was assumed that the heat contribution due to snowfall was negligible compared with the latent heat supplied by rainfall which subsequently froze on the glacier surface. Rainfall was measured by the accumulation over a twelve hour period of rain in a simple measuring cylinder/funnel arrangement.

(c) Conducted Heat Flux to the Glacier Surface

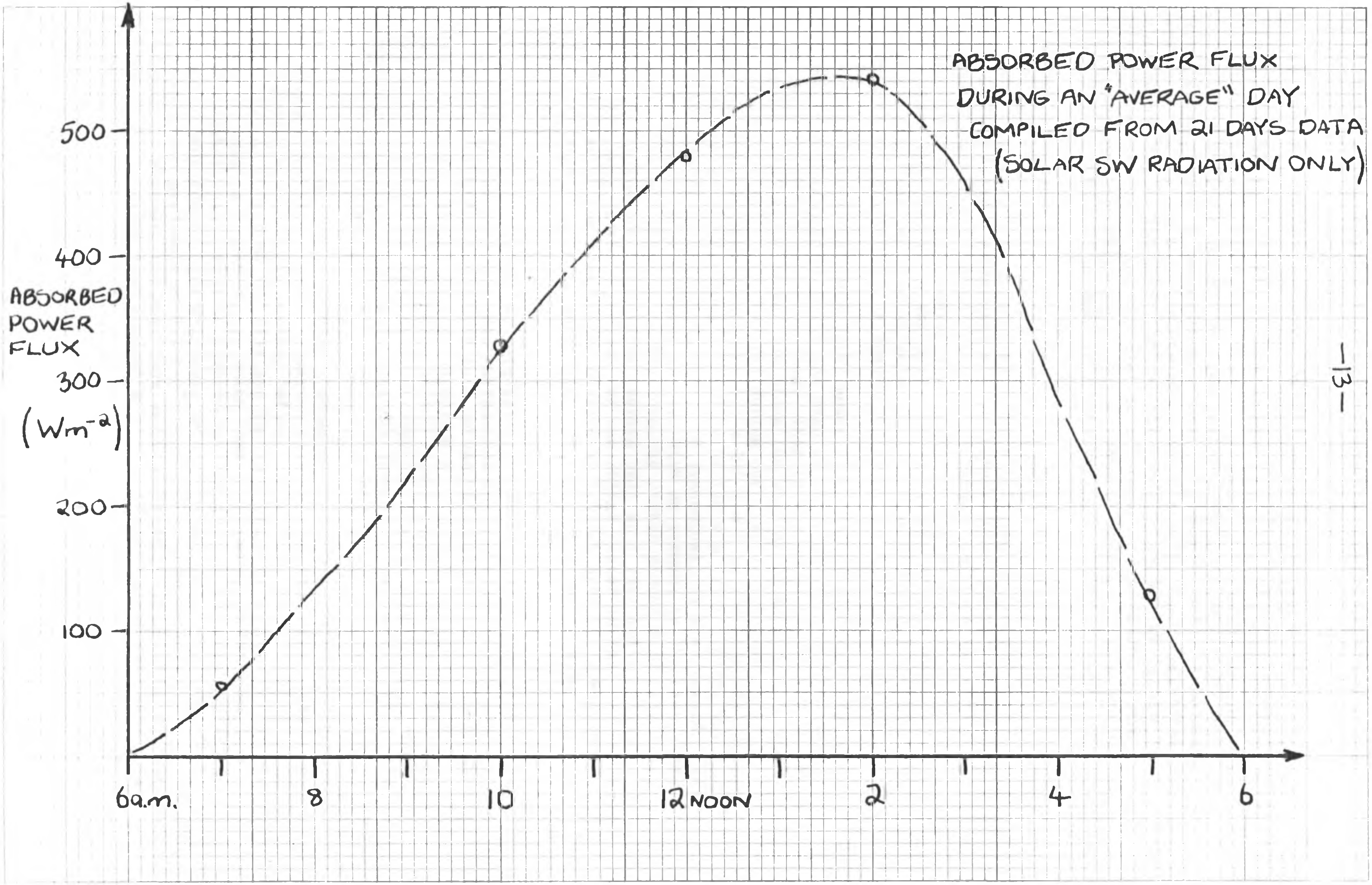
This was estimated by measurement of the temperature gradient below the surface using thermocouples buried at depths of 60cm and 2cm. Readings were taken at 6 hourly intervals.

(d) Sensible Heat (Heat transferred from the atmosphere to the glacier surface).

Because sensible heat is due to turbulence at the air/ice interface rather than simple molecular conduction, the theory involving heat transfer is more complicated and at best only a crude approximation to reality. The theory used (Paterson, W.S.B.) involved measurement of windspeed and temperature gradients above the surface. This was done at six hourly intervals using hand held anemometers and thermocouples, measurements being taken up to 2m above the glacier surface.

(e) Condensation/Sublimation

Because condensation (to ice) and sublimation involve two latent heats, the small masses involved can lead to relatively large energy contributions. It was initially intended to measure these terms, but since the area of the glacier under observation was covered heavily in debris sublimation could not occur.


ABSORBED POWER FLUX
DURING AN "AVERAGE" DAY
COMPILED FROM 21 DAYS DATA
(SOLAR SW RADIATION ONLY)
ABSORBED
POWER
FLUX
(Wm-2)
500
400
300
200
100
6a.m.
8
10
12 NOON
2
4
6

(f) Ablation

Due to the moraine covered surface, the usual method of ablation measurement involving measurement of surface movement against insulating stakes buried to depth in the ice was inapplicable here. Unfortunately, this meant that an indication of overall error in the energy balance by a comparison method was not possible; if all terms in the equation were known, the overall energy inbalance as found by experiment is a measure of the order of magnitude of the error involved.

RESULTS

Ideally, a more detailed study should employ field chart recorders enabling a continuous plot of temperatures and radiation to be made over a sustained period. Due to the harsh conditions and simple nature of the project discrete readings were taken at regular intervals for a three week period in the hope that a suitable average would be obtained which was representative of climatic conditions and the thermal balance of the glacier during August/September.

A plot of incident solar power flux against time was compiled for one 'day', each point being the mean of readings taken at that time each day over the three week period. This is corrected for albedo which averaged 0.17 (This is rather low since the glacier is moraine covered, and rarely completely snow covered during our visit). Integrating by graphical methods gives a total of 1.3×10^7 J m^{-2} in the 'average' day corresponding to a continuous power flux of 154 W m^{-2}. The plot, which under theoretical circumstances should be sinusoidal, is skew towards the afternoon because of the crater shape. With no opening to the East, the sun only rises and shines directly into the crater around 8.30 a.m. and even then strikes the ice covered eastern wall at a very small oblique angle. However, in the afternoon the sun shines nearer to the perpendicular of the massive ice covered wall which acts as an enormous reflecting dish - light is very bright in the crater during a sunny afternoon.

A total of 930ml of rain fell into the funnel (100mm diameter) during the 21 day period - this corresponds to an average of 5.6 litres M^{-2} per day of which 1.4 litres fell between 6 p.m. and 6 a.m. (overnight) with 4.2 litres falling during the period 6 a.m. to 6 p.m. (daylight). Taking the latent heat of fusion of ice (i.e. energy released by water on freezing) to be 335 kJ kg^{-1} this corresponds to an equivalent continuous power input of 21.7 W m^{-2}, significantly less than the power input of 154 W m^{-2} due to sunlight.

Of temperature gradients measured at different times of the day, the maximum positive gradient observed (i.e. increasing temperature with depths) occurred in early morning before the surface was exposed to sunlight. At this time the gradient had an average of 3.1 K m^{-1} over the 21 days. This is a much higher value than might be expected on an ice surface rather than a moraine covered surface (during the early period of the experiment temperature gradients were also measured beneath ice surfaces where gradients of 0.2 K m^{-1} were found to be more typical in the top layer). However, the heat flux associated with a temperature gradient of 3.1 K m^{-1} is still less than 40 W m^{-2}, much less than fluxes associated with solar radiation (assuming an estimated thermal conductivity of around 8-10 W m^{-1} K^{-1} for a sandy/pebble moraine where smaller particles are held together by ice). An important consideration is that gradients were only measured in the first metre below the surface. Heat fluxes here are much larger than those expected at depth since they are due to the daily cycle of heating and cooling rather than a long term steady heat flow through the glacier. This factor could mean that the conducted heat flux contribution to the long term thermal balance of the glacier is negligible compared with other contributions.

Temperature gradients taken above the surface in order to help evaluate sensible heat flux, averaged 0.3 K m^{-1} when extrapolated to give the gradient at the surface. Windspeed gradients at the surface averaged around 1.3 $(mS^{-1})m^{-1}$, although of all measurements taken, these were the most widely varying and probably least accurate. Taken in pairs of data, the windspeed and temperature gradients were used to calculate power fluxes for each day according to the theory outlined in Paterson's 'Physics of Glaciers'. An average figure of 11 W m^{-2} was calculated for the 21 day period.

Glacier Areas

In addition to measurements made relating to the thermal balance study, rough calculations of glacier areas were carried out from photographic coverage of the crater floor. The photographs were taken from part way up the Northern inside wall of the crater and distance was 'calibrated' by placing two conspicuous markers (a tent and an orange bivouac bag) 20m apart. Angular effects due to the oblique viewpoint were taken into account. However, these errors are far smaller than discrepancies arising from difficulty in pinpointing the glacier boundaries amidst the snowy moraine covered terrain. The following areas were found for the two glaciers in the crater, and are compared to information supplied to the World glacier Inventory in 1978 by Hastenrath.

	Measured area (1985)	1978 Area
Eastern Glacier	60 (±15) x $10^4 m^2$	80 x $10^4 m^2$
SW Glacier	17 (± 5) x $10^4 m^2$	20 x $10^4 m^2$

Summary of Energy Flux Averages

Net SW Solar Radiation	154 W m^{-2}
Latent Heat from Rainfall	22 W m^{-2}
Conducted Heat Flux	40 W m^{-2}
Sensible Heat Flux	11 W m^{-2}

Conclusions

Despite El Altar's position close to the rain forests which lie to the East, it is clear that heat supplied to the glacier surface by rain brought in by the warm humid air currents from the East is not the dominant factor contributing to ablation during August/September. Since November through to February is known as being the dry season near Altar it seems unlikely that heat supplied by rainfall is comparable to solar energy on an annual timescale.

Low albedo (due to the rocky moraine surface which absorbs far more solar energy than snow or ice) seems to be the crucial factor. The average albedo of 0.17 compares with typical figures of 0.5 to 0.8 for ice covered glaciers; i.e. with a debris covering, around twice as much energy is being absorbed than with an icy surface. With part of the glacier situated in the crater floor where constant rock falls keep the ice well covered, there is little hope for this part of the glacier to survive the massive extra energy inputs incurred without large mass losses. It seems unlikely that the glacier will remain in the water floor for many more decades, but will perhaps retreat leaving only the hanging section still flourishing on the Eastern inside wall of the Caldera.

References

Hastenrath, S: The Glaciation of the Ecuadorian Andes; A.A. Balkena/Rotterdam.

Paterson, W.S.B.: The Physics of Glaciers; Pergammon

STUDY OF POLYLEPIS INCANA

Summary

The tree Polylepis is able to grow at extraordinarily high altitudes. On El Altar a stand of Polylepis Incana grows well above the tree line.

As a preliminary study of the specialisations required for tree growth at this altitude, the daily variation of air, leaf, bark and ground temperatures was measured. An attempt was also made to measure the transpiration rate of the tree throughout the day.

Results indicate that, at this altitude, this near to the Equator, low temperatures are not the limiting factor for tree growth. It has been suggested that high levels of ultraviolet radiation could be responsible for this.

Introduction

Tree growth at high altitude is believed to be limited by low temperatures. In tropical areas, such as Ecuador, there are large daily fluctuations in temperature, above 3600m: this daily freezing and thawing causes severe physical stress to leaf cells. In these temperature regimes, soil more than 30cm below the ground surface never reaches a higher temperature than 2-5°C. As tree roots cannot absorb water below 4°C, this severely restricts the availability of water. In theory, these two factors should prevent tree growth.

However, trees of the genus Polylepis are notable for their ability to grow at high elevations. In South America, where the natural treeline is 3200-3400m, they frequently grow above 4000m. It is clear that these trees must possess a range of specialisations to enable them to survive in these harsh conditions, yet very little fieldwork has been done to determine what these specialisations are.

On El Altar a stand of Polylepis Incana grows at an elevation of 3900-4100m. We decided that these trees would be suitable subjects for some preliminary studies in this area. The aims of the studies were:-

Firstly, by a series of temperature measurements, to determine the temperatures experienced by the tree, throughout the day.

Secondly, since water availability seems a critical factor, to measure the variation of leaf conductance during the day.

Methods

Temperatures were measured hourly from 5 a.m. (an hour before sunrise) to 7 p.m. (an hour after sunset), using Ni/Al thermocouples. Measurements were taken of air, leaf, ground and bark temperatures.

Polylepis Incana has a bark up to an inch thick, composed of many thin layers. Studies on the Andean giant rosette plant show that the layer of dead leaves, found around the stem of this plant has vital insulating effects. The measurement of bark temperatures was to determine whether the bark of Polylepis Incana might have a similar function. A section of bark was gently pulled away from the tree, and a thermocouple inserted under it. The bark was then taped back into position. Temperature readings were taken from this thermocouple, and from another on the outer surface of the bark.

Leaf temperatures were taken from two widely separated leaves. The very small leaf size made it impractical to tape thermocouples to the leaves and an attempt to glue the thermocouples to them instead, was unsuccessful. Readings were taken by holding the thermocouple against the leaf for a few seconds at a time.

Ground temperatures were measured at the ground surface, and at a depth of 50cm.

Leaf Conductances:

Transpiration rates were measured every two hours from 5 a.m. to 7 p.m. A triple beam balance was used to measure weight loss from a twig bearing 40-60 leaves. As the balance is very sensitive to air movements, these measurements were carried out inside a tent. Weight loss was measured over a 15 minute period.

Wet and dry thermometers were used to measure the relative humidity inside the tent. Relative humidity in the leaf was assumed to be 100%.

Total leaf area was measured by approximating the leaf shape to an ellipse and measuring the length and width of each leaf with a millimetre rule.

Leaf temperature was measured at the start of the experiment using a thermocouple.

Using tables of the saturated water content of air, the concentration of water inside the leaf (C_0), and the external concentration of water (C_1), were found.

The conductance of the leaf was then calculated:

$$\text{Conductance} = \frac{\text{Rate of transpiration per unit area of leaf}}{C_0 - C_1}$$

Results

Both general observations and accurate temperature measurements showed that weather conditions were not as severe as expected. In the 3½ weeks we were at Altar, it froze overnight on very few occasions. Typical air temperatures an hour before sunrise (about the coldest time of day) were 3-5°C.

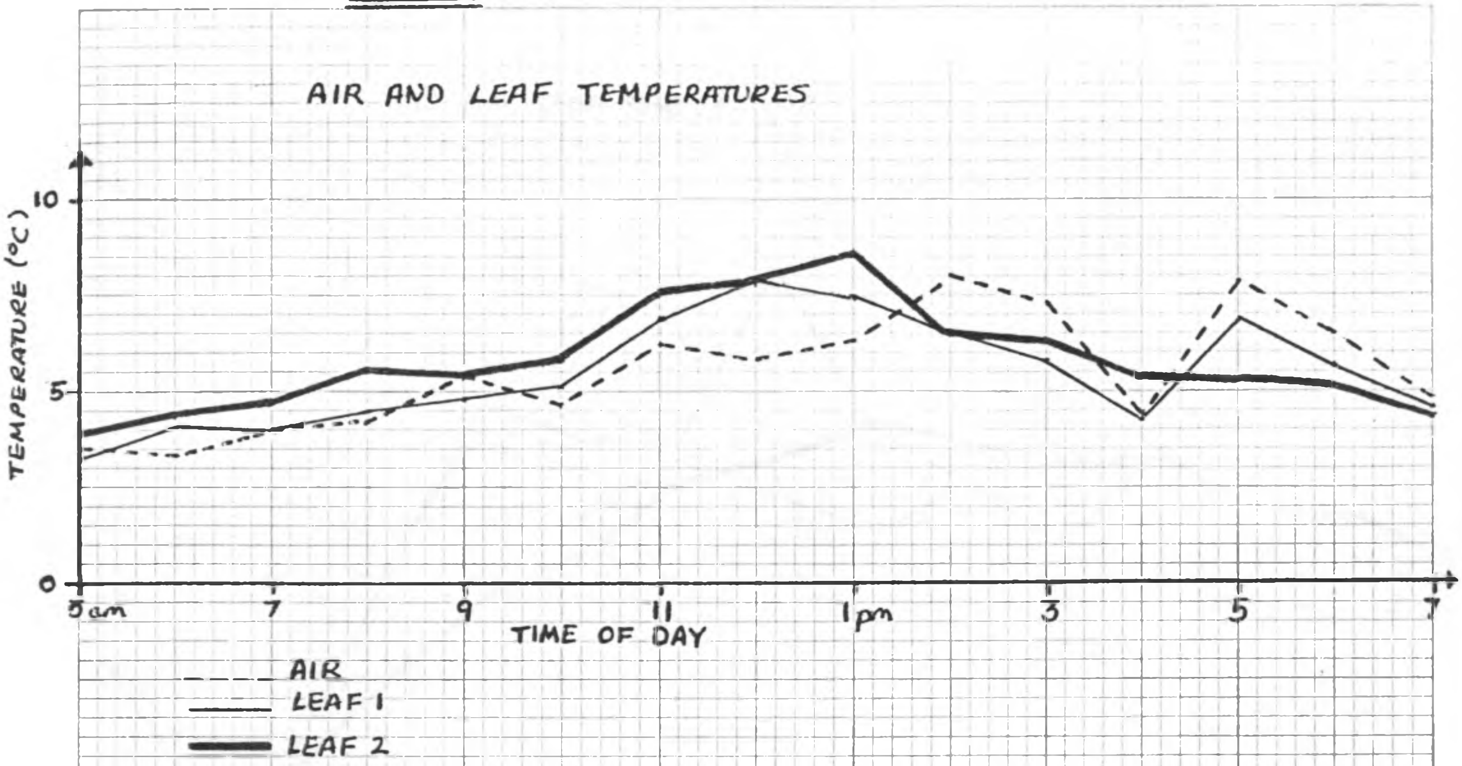
Ground temperatures, at a depth of 50cm, were almost constant at 7-8°C. Therefore, I estimate that there should be no problems with water uptake for about 1 metre below the ground surface. Given the very high rainfall at Altar, this suggests that low water availability is not a limiting factor for the growth of these trees.

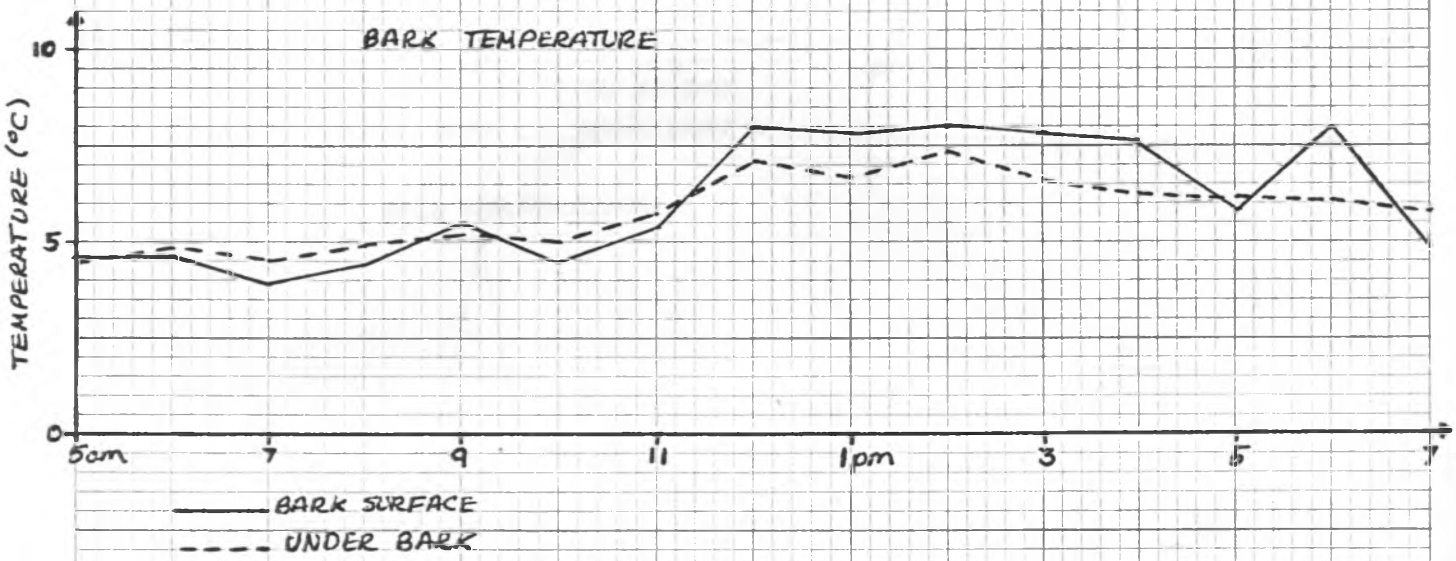
The bark of Polylepis Incana did show a significant insulating effect, both from the rapid temperature fluctuations during the day, and from the cold at night. The outer bark surface showed temperature fluctuations of up to 9°C in an hour, while underneath the bark, these fluctuations were reduced to less than 5°C in an hour. Early morning measurements showed that cooling of the tree overnight had resulted in a temperature difference of about 1°C between the inner and outer surfaces of the bark.

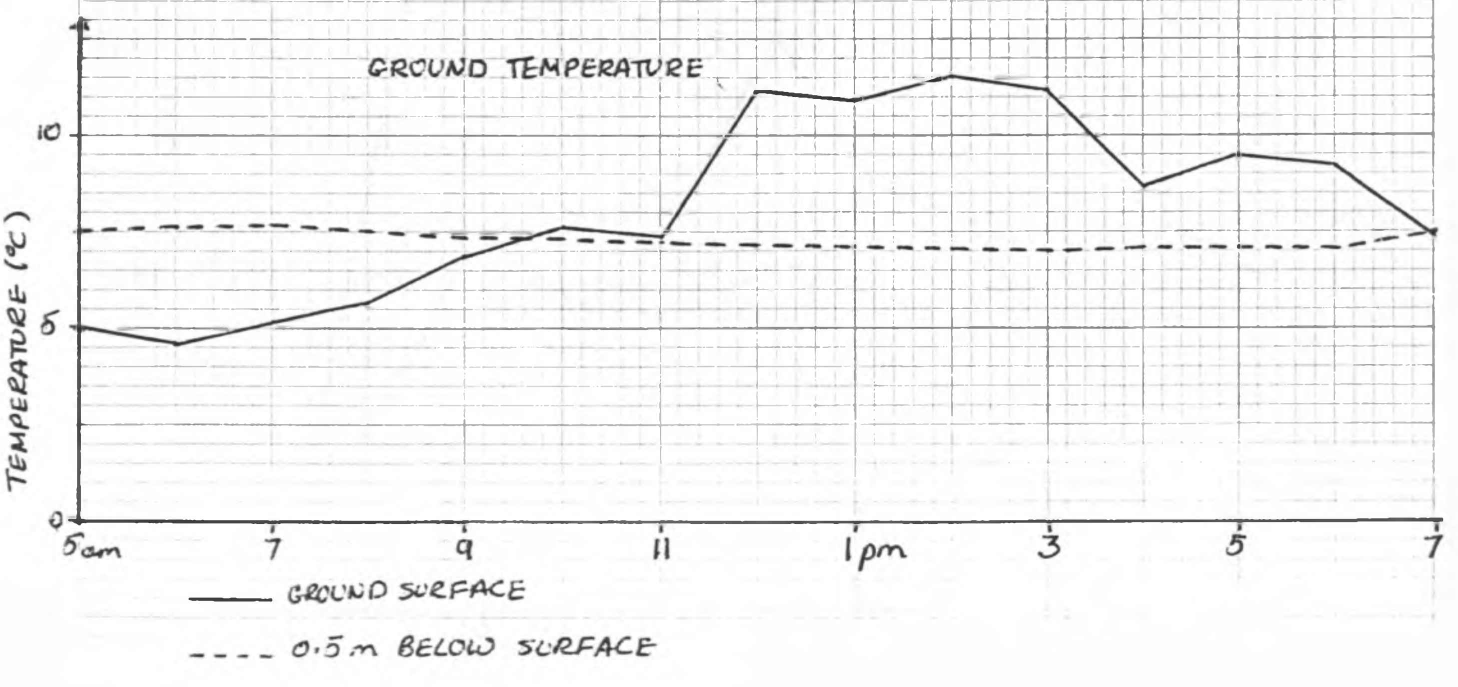
Leaf conductance measurements were less successful. The transpiration rates measured were at the very limits of accuracy of the triple beam balance. Some results were obtained but they were not consistent. In view of the fact that water availability does not appear to be constraint on tree growth, I have not included them.

Since, in Ecuador, and at these altitudes, low temperature does not appear to preclude tree growth, the reason for the natural tree line occurring at 3400m must be sought elsewhere. One possible reason for the lack of trees above 3400m might be the very high UV levels found at these altitudes. Mr. Alan Miller of the Overseas Development Administration, has carried out an experiment, providing artificial shading for seedlings at 4000m. The shading was provided by areas of hessian cloth supported above the trees. Shaded seedlings showed markedly improved growth. However, measurements of temperature, humidity and windspeed showed that the only significant difference in environment between shaded and unshaded trees, was the amount of sunlight reaching the seedlings. Obviously more work would have to be done to test this very tentative theory.

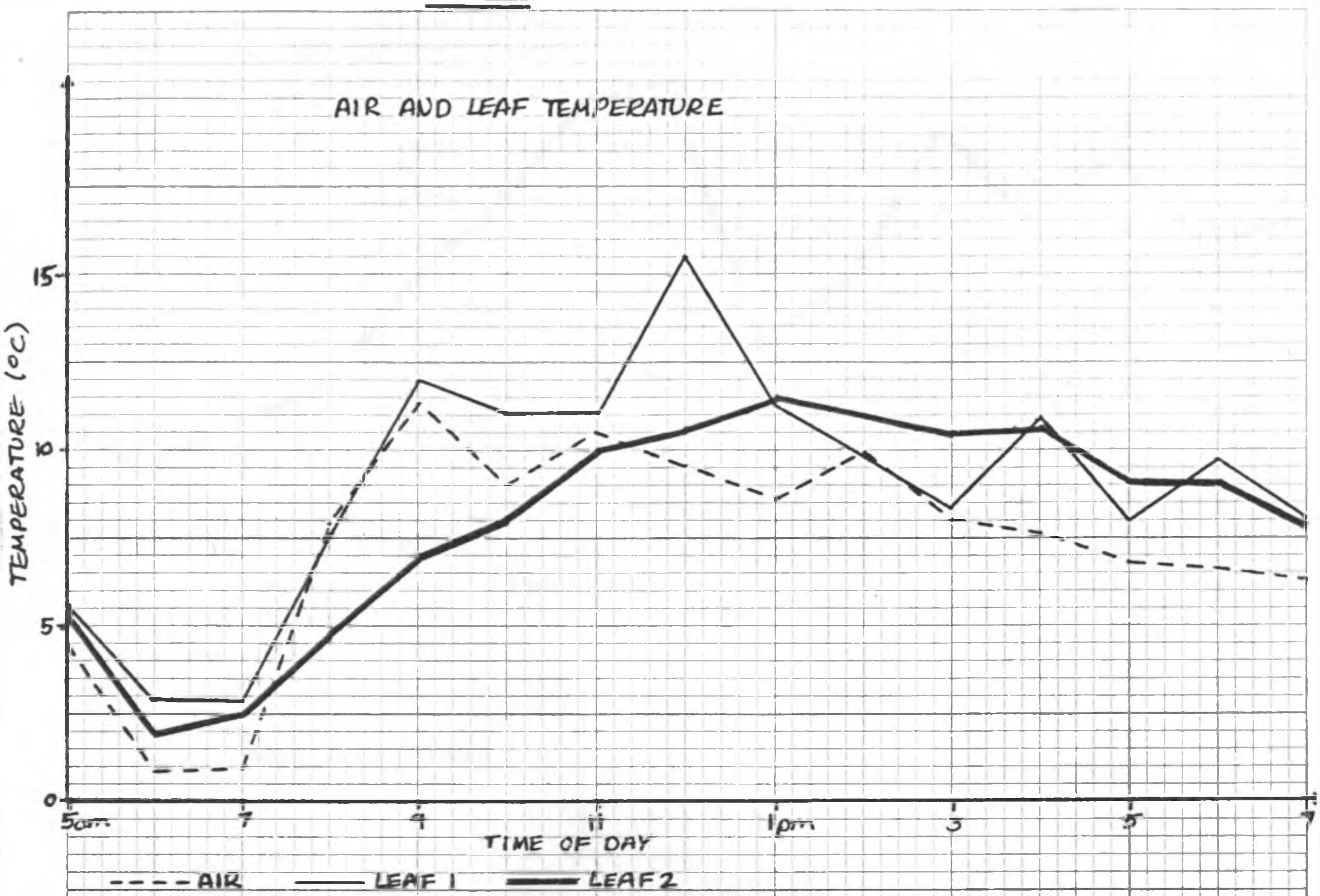
DAY 1

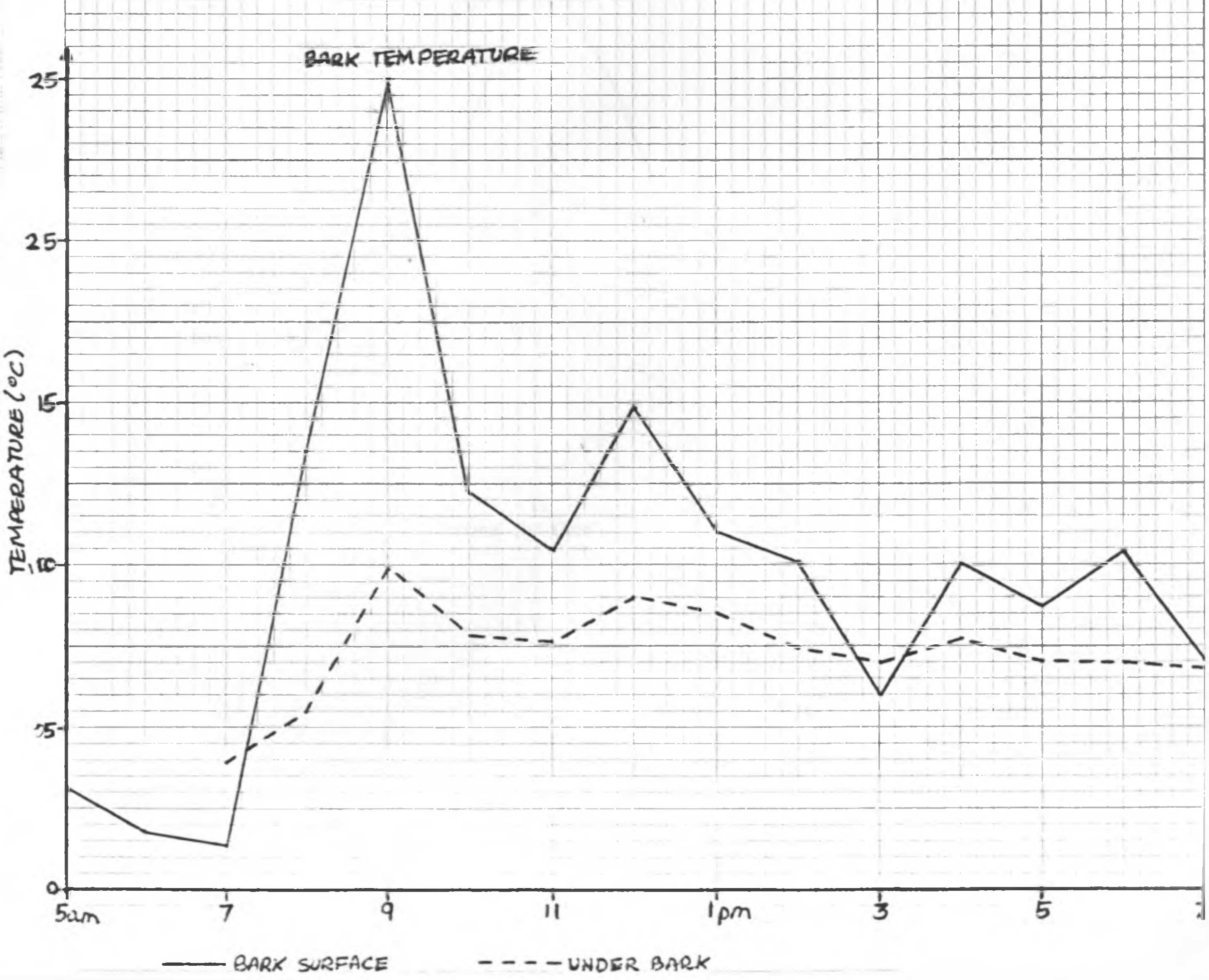

AIR AND LEAF TEMPERATURES
TEMPERATURE (°C)
0
5
10
5am
7
9
11
1pm
3
5
7
TIME OF DAY
AIR
LEAF 1
LEAF 2


BARK TEMPERATURE
TEMPERATURE (°C)
0
5
10
5am
7
9
11
1pm
3
5
7
BARK SURFACE
UNDER BARK

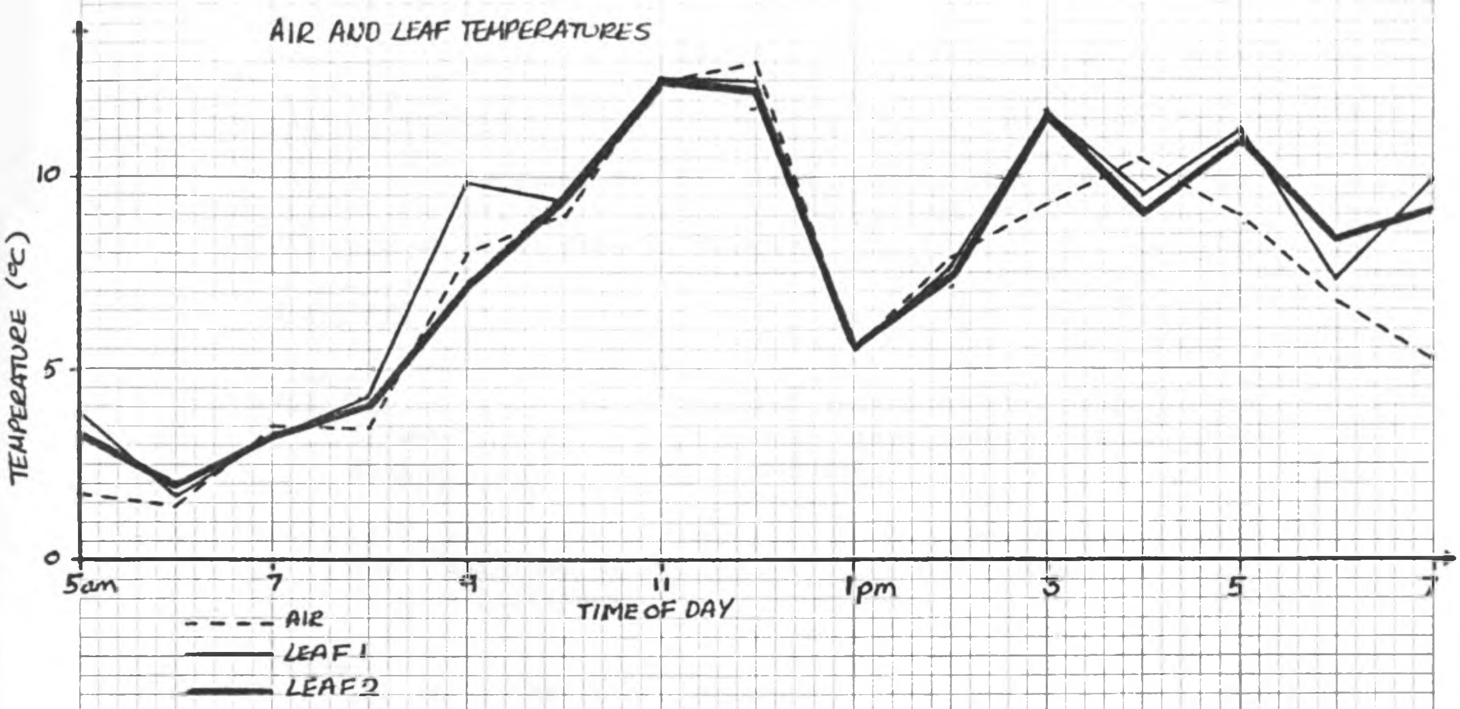

GROUND TEMPERATURE
TEMPERATURE (°C)
0
5
10
5am
7
9
11
1pm
3
5
7
GROUND SURFACE
0.5 m BELOW SURFACE

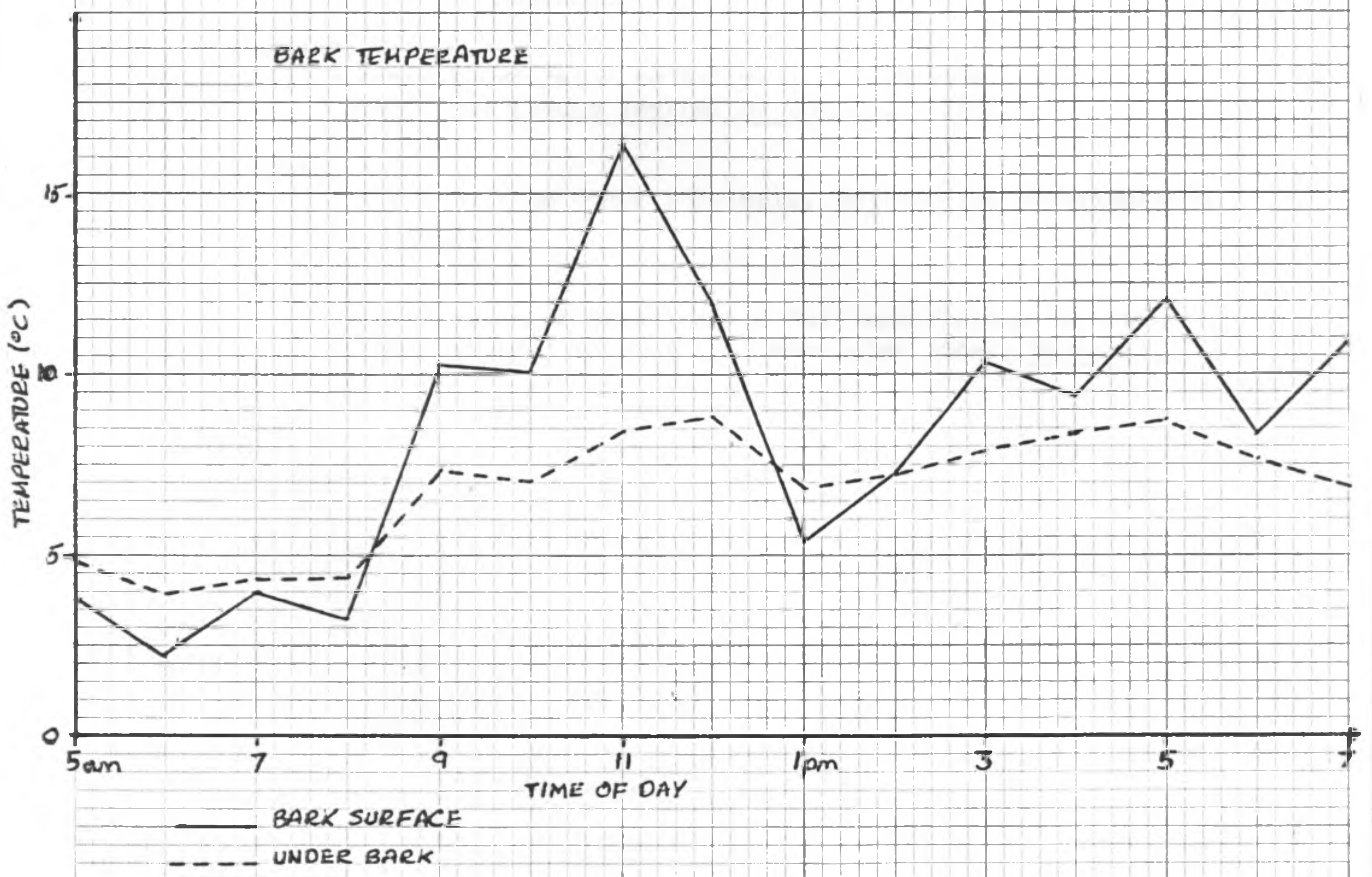
DAY 2


AIR AND LEAF TEMPERATURE
TEMPERATURE (°C)
15
10
5
0
5am
7
9
11
1pm
3
5
7
TIME OF DAY
AIR
LEAF 1
LEAF 2


BARK TEMPERATURE
TEMPERATURE (°C)
25
25
15
10
5
0
5am
7
9
11
1pm
3
5
7
BARK SURFACE
UNDER BARK

DAY 3


AIR AND LEAF TEMPERATURES
TEMPERATURE (°C)
0
5
10
5am
7
9
11
1pm
3
5
7
TIME OF DAY
AIR
LEAF 1
LEAF 2


BARK TEMPERATURE
TEMPERATURE (°C)
0
5
10
15
5am
7
9
11
1pm
3
5
7
TIME OF DAY
BARK SURFACE
UNDER BARK

Acknowledgements

I would like to thank Dr. Ed Tanner and Dr. P.J. Grubb, of the Botany Department, for all their advice on the project and also Alan Miller for his help while we were in Ecuador.

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THE DIRT CONE STUDY

Aims

This project aimed to provide a quantitative study of the transition of cryoconites into dirt cones on the glacier surface. Cryoconites are debris-filled pits in the ice surface, formed when debris on the surface absorbs solar radiation and melts the ice underneath. The cryoconites then fill up with more debris which is washed in by surface meltwater. We intended to test the theory that there is a critical depth of debris in the bottom of the cryoconite, above which the insulating properties of the debris become more important and the ice around starts melting faster, leaving a debris covered cone.

Proposed Measurements, Methods and Conclusions

The intention was to clear all the surface debris from a reasonably flat area of glacier and perform the following experiments:

(i) Set up a number of circular patches of natural moraine debris on the glacier surface. These patches would all have the same area of ~ 70cm in diameter but be of different thicknesses (in the range 1cm - 15cm). We would observe these twice a day (morning and evening) and measure the height of cone/depth of cryoconite formed so that we could evaluate the growth rates for different thicknesses of debris, and find the critical thickness of debris at which this rate becomes positive; i.e. a dirt cone is formed.

(ii) Once the cones had reached a steady state we would measure their maximum height and the thickness of debris now left on the sides of the cone; Our conjecture being that the height of the cone when it reached a steady state would be such as to give the same thickness of debris in each cone. Also we intended to use a clinometer to measure the angle of inclination of the sides.

We would then select one of the larger cones and embed thermocouples throughout the debris layer to measure the thermal gradient across it in the steady state, and thus calculate the thermal conductivity of the layer.

(iii) Repeat the above experiments, this time using the same thickness of debris layer at each site, but roughly sorting the debris into different grain sizes for each site, allowing us to assess the effect this has on dirt cone formation.

Problems Causing us to Abandon the Project

Unfortunately when we arrived at the glacier we discovered that it was already covered to a depth of at least ½m with debris, thus making it totally impractical to clear an area to do the projects in. The only parts of the glacier not already covered in debris were those where it was at such a steep angle that the debris slid off; obviously no good for building dirt cones on.

Looking at the lateral moraines high up on the sides of the crater, it was obvious that the glacier used to fill the crater to a depth of ≈ 100m and that much of the debris that it had contained was now deposited on the surface of the present glacier.

SOIL ANALYSIS PROJECT

Introduction

During the last eruption of Cotopaxi in 1877, its glaciers melted and torrents of mud, boulders and volcanic debris were washed down into the surrounding valleys. This is when the flat plain 'Limpio Pongo' formed in the valley north of the volcano. Since then this potentially fertile plain of lava-based soil has remained devoid of vegetation except for a covering of grey lichen, contrasting sharply with the normal shrubs, flowers and grasses growing on the valley sides.

We were introduced to the area by Alan Miller, a forestry expert who had already analysed the soil for nutrient minerals (Ca,K,Na etc) and found no deficiencies to account for the lack of plant growth. We decided to collect and analyse more samples for toxic trace elements such as lead and arsenic.

Method of Collection

Samples of about 300g of soil from 10cm below the surface were placed in identical clean plastic bags using a clean spoon. Samples were taken from the following sites:-

1) Limpio Pongo floor (barren area)

2) Limpio Pongo floor (Western end where some stunted trees had grown in a test plantation site).

3) Limpio Pongo valley sides (normal vegetation).

4) El Altar crater moraine (less than 25 years old, with sparse grasses and flowers.

5) El Altar ridge moraine (well vegetated with grasses and trees)

6) El Altar lateral moraine (tall tussock grass and low flowering shrubs).

Method of Analysis

We decided to analyse the samples using the ICP Spectrometer at Kings' College, London. This technique (Inductively Coupled Plasma Emission Spectrometry) allows rapid semiquantitative analysis of up to 50 elements at once, thus giving a scan over a wide range of possible toxic elements and an indication of whether they are present in toxic concentrations.

Sample Preparation

At the Bullard Geochemistry Labs in Cambridge, the samples were dried in an oven at 50°C, ground to a fine powder in an agate pestle and mortar, and treated in a low temperature asher where organic matter is removed by reaction with a plasma of oxygen ions. About 0.1g of each was dissolved in hydrofluoric acid to convert all the metals present into fluorides, then evaporated to dryness and repeatedly dissolved in nitric acid and evaporated until all the fluorides were converted to nitrates.

This was because not all fluorides are soluble, and the metals must all be in solution for analysis. Finally the samples were dissolved in 10ml of hydrochloric acid.

ICP Spectrometry

In this technique, a very small amount of solution is taken into the machine through a capillary tube and sprayed into a chamber containing a plasma of argon ions at 1000°C. The elements in the sample absorb energy to promote their outer electrons into higher energy levels, and when the electrons decay to their ground states they emit radiation in the visible or UV range of the spectrum at a frequency which is characteristic of the element.

We used a program which analysed for 29 elements including the toxic trace elements Molybdenum, Cadmium, Arsenic and Antimony, and the transition metals Copper and Lead. To calibrate the results we ran two standard solutions containing known concentrations of these elements.

Standard 1: 20ppm each of Co, Cu, Cr, Zn, Mo, Pb, Cd, Bi, Ce, Y, La.

Standard 2: 20ppm each of As, Sb, Ba.

The results were presented by the printer in actual concentrations in the soil assuming that exactly 0.5g soil was dissolved in the 10ml HCl acid. A small correction was necessary to account for the different weights in the samples.

Results

	Cu	Pb	As	Cd	Sb	Mo
Limpio Pongo						
1) Floor (barren)	44	0	760	26	77	18
2) Floor (plantation)	48	0	828	26	79	18
3) Sides	47	0	671	27	68	16
El Altar						
4) Crater moraine	74	18	782	21	99	25
5) Ridge moraine	71	0	661	20	64	16
6) Lateral moraine	79	2	719	22	77	20

Conclusins

1) There is an apparently high level of arsenic in all samples but as this is present in soils from the well vegetated areas (samples 3 and 5) it is probably not toxic. However, both arsenic and antimony are present in slightly lower concentrations in samples 3 and 5.

2) There are no significant differences in toxic trace elements between samples 1,2 and 3.

3) There are slight differences in levels of all elements, especially Cu, between Limpio Pongo and El Altar, as would be expected. The differences are not great because the two volcanoes are in the same volcanic province.

4) The results do not support the hypothesis that the lack of plant growth is due to toxic trace elements. However, organic poisons such as cyanide could be present.

5) The area floods every two to three years, and it has been suggested that this is responsible for the lack of woody plant growth. However, a more luxurious growth of grasses and flowers would be expected between floodings, instead of the grey lichen covering. Normal flood plains have rich vegetation but this one does not have a constant supply of fertile alluvium.

MOUNTAINEERING

El Altar

There has only ever been one ascent of any of the peaks of El Altar from the inside of the crater because the walls are so steep. The easiest lines of ascent (still quite difficult) are from round the back entailing a long trek in. We did not do much climbing there, our only ascent being made by Martha and Dave on Canonigo Chico on one end of the crater edge. We did however, do a lot of backpacking around the back of the crater and walking up onto the ridges for the views.

Cotopaxi

For their five days free from the project, Dave and Nigel travelled to Cotopaxi to make an attempt on this the second highest mountain in Ecuador (19,700 ft.). After hitching up to the climbers' hut we set out at midnight under a clear sky following the route described in the guide. After climbing for 5 hours it became obvious that this route was now impassible since a huge chasm had opened up barring the way. Back at the hut we found some Americans who knew the new route which traversed for 2km anticlockwise round the mountain before going up. We set off with them at midnight the next night but it soon clouded over and started snowing, reducing visibility to 20ft. due to complete white-out conditions. There was one steep section which we roped up for and climbed in 2 pitches, then we crossed a crevasse field and started plodding up to the summit. By 10 a.m. we had reached Yanasacha, about 600ft. from the top. By this time the snow was so deep and soft that we sunk up to our waists and the person making the trail could only flounder up about 3 steps before having to rest from exhaustion and the altitude. We decided to turn back and arrived back at the hut at about 2p.m. after 14 hours climbing.

Chimborazo

After spending 3½ weeks at over 14,000 ft. on El Altar we decided we would be acclimatised enough to attempt this the highest mountain in Ecuador (20,600 ft.) and, because of the equatorial bulge, the point on the earth's surface furthest from the centre of the earth. Eventually only Dave, Nigel, Martin and Judith set out at midnight because the other two were ill with stomach problems. We trudged up the mountains in the dark and when we started on the ice Judith's crampon broke, forcing her to return. There was only one technical section, a gulley in a rock band,after that the main problem was tiredness due to the deep snow which quickly softened up after sunrise. So eventually Dave, Nigel and Martin reached the summit with fantastic all round views and then set off back down the vast snow slopes being careful not to let their crampons ball up with the snow. The round trip up and down took nearly 13 hours.

APPENDICES

Equipment and Food Report

We experienced quite severe conditions whilst up on El Altar: lots of rain and temperatures down to -10°C, so we had to have good equipment. Luckily we were greatly helped by a number of manufacturers who gave us generous discounts on their equipment. Here is a brief summary of the major items of equipment that we took with us. Everything was packed into 6 large rucksacks and 3 huge kit bags.

Tents

2 3-man Vango Force Ten tents (nylon outer, cotton inner). These were used at base camp, one as a store tent to keep our food dry and the other slept the 2 people always manning base camp.

1 2-man Vango Force Ten tent. This was pitched high up inside the crater at 15000ft., near our glacier and provided a rather cramped home for the two people who were doing the glaciology at any one time.

1 Robert Saunders Backpakcer II. We added an extra groundsheet cut out of heavy duty polythene to protect the thin sewn-in groundsheet and we used this lightweight 2-man tent for backpacking.

We had 3 large plastic kit bags in which we put our rucksacks when using the 2-man tents to give us more room inside the tents.

We would definitely recommend the use of 3-man tents when sleeping 2 people for any length of time. Often at glacier camp we would have to spend long periods of time lying on our backs, sitting out bad weather, but we had arranged it so that nobody spent more than 3 days at a time there, so it was often quite a relief to get back to the roomy 3-man Vango at base camp.

Cooking Equipment

We used 3 optimus stoves.
Optimus 8R (small petrol stove) for backpacking
Optimus 119 (small multifuel stove) at glacier camp.
Optimus 111 (large multifuel stove) at base camp.

All the stoves were fitted with pumps to cope with the low pressure at our altitude.

We ran the stoves off petrol and paraffin, but strongly recommend the use of paraffin (sold very cheaply under the name 'Kerex'). The Ecuadorian petrol was very dirty and caused the stoves to clog up. Near the end of our stay at El Altar, the mechanism moving the cleaning needle on our small multifuel stove broke, leaving 2 people at glacier camp without hot food for 2 days since that was one of the spare parts we had not brought with us.

We bought a large aluminium cooking pot and 2 large plastic fuel containers very cheaply in Quito, thus saving a lot of bulk on the flight.

Clothing

Probably the most useful piece of clothing from the warmth point of view was the Helley Hansen lightwear thermal underwear (thin polypropalene long sleeved top and longjohns). This was extremely light but, being skin-tight provided a good insulation layer which also allowed sweat to pass through. Most people also found it very comfortable to sleep in them when the weather was cold.

Our Tog 24 (General or Tokyo) fibre pile jackets proved extremely useful for general use when at base camp or travelling around and had the useful feature of a zipped inside pocket to keep money in when walking around towns. However, they were a bit bulky to carry in our rucksacks.

We were all equipped with thermal inner gloves, water/wind -proof outer mitts, a ballaclava and a pair of small snow goggles which cut out 95% of incident U.V. light, preventing snow-blindness.

Waterproofs

You will probably already have gathered that it rained torrentially on El Altar, so decent waterproofs were absolutely essential. We were most fortunate to be offered an extremely generous discount from Sprayway Ltd., so we all bought full Gore-Tex waterproofs: either the 'Snipe' in ordinary Gore-Tex or the 'Kestral' in heavier weight strata Gore-Tex. Martin wore a Sprayway insulated jacket which performed very well, taking the place of a fibre pile and waterproof. Sprayway gave us each a pair of gaiters in the hard-wearing strata Gore-Tex. These proved absolutely essential since the El Altar area was very wet and we always had to wade up to our knees in mud on the path. At the end of the day we would take off the gaiters completely black with mud, but our socks underneath remained perfectly clean and dry. When climbing mountains we obviously needed them to cope with the deep snow.

Footwear

Everyone had a pair of training shoes plus 1 pair of fairly heavyweight leather boots with steel shanks made by Zamberlan or Scarpa. They all performed very well apart from Judith's old pair of boots with a ½ length shank which had become too flexible to take crampons adequately. Although plastic boots would have been warmer in the snow, we decided they would be too rigid and uncomfortable for general walking. Whenever our boots dried out, we proofed them with Nickwax.

Climbing Gear

We each had a long ice axe and a pair of Salewa adjustable crampons with French-style neoprene straps. As group equipment we took a 9mm climbing rope, 3 harnesses, 6 slings, an ice hammer, 2 drive in ice screws and 2 deadmen. The ice protection, ice-hammer and 2 of the ice axes were sold to us at trade price by Mountain Technology Ltd., and we were particularly impressed with the walking axes. Since ascents of the major peaks require pre-dawn departures, we took 3 headtorches donated to us by Wonder Portable Power (U.K.) Ltd. These were also very useful when, for example, cooking in the tent since they left both hands free.

Miscellaneous Useful Items

Cigarette lighters	- much easier than matches when lighting a stove in the wind and rain.
Strong Plastic Tape	- for a wide range of repairs.
Tin Foil	- useful as a wind shield for the stove.
Large Bin Liners	- to line sacks and keep everything dry.

Maps and Books

Maps can be brought from the Instituto Geographico in Quito, but we found the large scale maps useless. It is however, worth buying their map of the whole of Ecuador for travelling around. Aerial photos can also be obtained from the Instituto and they, when viewed with stereo viewers give a better idea, but they are expensive to buy. It is definitely worth buying the book 'Climbing and Hiking in Ecuador' by Rob. Rachowiecki, published by Bradt Enterprises. This includes useful sketch maps of all the important mountains and describes in detail how to approach and climb them. It also has plenty of other useful and interesting information regarding travelling around Ecuador. It is however, worth checking the ascent routes of mountains like Mt. Cotopaxi at the climbing huts, since the best lines often change due to new crevasses opening up.

Food

We bought most of our food locally: huge sacks of potatoes, vegetables, rice, pasta and lentils plus plenty of oranges and bananas and a few tins of sausages, mackerel, sardines and tuna. The tinned food was very expensive and heavy so we ate mainly vegetable stews for dinner leaving tins of sardines and pate to eat with biscuits for lunch. It is worth bringing packets of meaty soups from England to add to the vegetable stews. Local Ecuadorian packets of soup are expensive and invariably chicken flavour. We brought some Batchelors dried meat and 4 packets of TVP (texturised vegetable protein) donated to us by Itona because dried meat cannot be bought in Ecuador. This was used for backpacking and when we had to carry it up to the glacier camp. The TVP was good in that it only needed adding to boiling water. However, it was very bland and required plenty of spices to make it edible. Some things don't work very well at altitude, e.g. spaghetti becomes very stodgy. At our base camp (14,000 ft.) water boiled at only 85°C.

Selling Gear

Because of high import tariffs, decent climbing and backpacking equipment is very expensive and hard to obtain in Ecuador. There are a number of ex-pat Britons and Americans who will give you good prices for your equipment. There are also a few wealthy Ecuadorians who go climbing. When we were staying in climbing huts we were often approached by climbers wanting to buy our gear. In the end we sold about half our climbing gear, a stove and a tent, lightening our loads for the flight home. The day before we left, a German even offered Nigel 40 dollars for the trousers he was wearing in the centre of Quito. It is best to sell direct to climbers but the two shops Campo Abierto and Equipos Cotopaxi in Avenida Seis de Diciembre will buy your gear at a lower price.

Medical Report

Our medical kit as supplied by the medical scheme was alarmingly heavy and bulky, filling two small haversacks (actually ex-army gas-mask bags), but we needed drugs for everything from sunstroke in the coastal lowlands to frostbite on the glacier, from fever in the jungle to altitude sickness at 16,000 ft. in the Andes. The kit survived admirably despite two months of being rained on, sat on, and thrown on and off Ecuadorian buses.

Fotunately none of our strong drugs were needed. However, while on El Altar, Martha developed Impetigo, a highly contagious British skin disease. This started as a blistery rash on the backs of her hands, and worsened into scabs after about two weeks. Using the handbook we diagnosed the correct treatment as Neomycin antibiotic cream, but then found that this was not supplied in the kit. We tried antihistamine tablets and various applications but with no success. On our return to Quito we found an English speaking doctor who detained Martha for a week of antibiotic treatment including Neomycin cream, so we were a little annoyed that it was not available in the kit. Although the treatment was successful, we learnt that one variety of Impetigo causes heart and liver diseases, and the harmless looking rash could have indicated a very dangerous condition.

We had no altitude problems, probably because we acclimatised in Quito at 10,000 ft. before moving on to our base camp at 14,000 ft. High factor suncream and lipsalve were essential at these heights and this near the equator, especially on snow. We received generous donations of these from several companies.

Diarrhoea was a constant problem, especially when faced with long bus and train journeys! We used Imodium, one tablet of which was effective for 6 to 8 hours, but mild gut infections could persist for 2 or 3 weeks. We treated all our water with Puritabs which were easy to use but gave an unpleasant taste of chlorine.

We consumed large quantities of Malaria tablets: Paludrine (2/day) and Chloroquine (2/week), but only encountered mosquitoes on the North coast of Ecuador, where the natives slept under mosquito nets. Despite being devoured by mosquitoes, none of us suffered any malarial symptoms. We used 'Jungle' insect repellent, which contains 80% active ingredient (diethylmetatoluamide). This was effective against flies in the jungle but powerless against the voracious coastal mosquitoes.

On the whole there were no serious problems and we were very pleased with the medical kit obtained from the Cambridge Expeditions Medical Scheme.

List of Drugs Carried

(* = drugs used)

Drug	Use	
Paludrine *	Antimalarial (prevention)	
Chloroquine *	" "	
Fansidar	" (treatment)	
Chloroquine	" "	
Piriton *	Antihistamine	
Aspirin *	Pain relief	
Paracetamol *	" "	
DF 118 tablets	Strong pain relief	
Gaviscon *	Indigestion	
Senekot	Laxative	
Imodium * (= Lomotil)	Anti-diarrhoeal	
Codeine phosphate	" "	(Kaolin and Morphine)
Flagyl	" "	(antibiotic)
Trimethoprim	" "	"
Penicillin V	Penicillin	
Ampicillin	"	
Erythromycin	"	
Terramycin	Rashes	
Stugeron	Travel sickness	
Mogadon	Sleeping tablets	
Frusemide	Altitude sickness	
Maxolon	Nausea	

Inoculations

Before leaving, all members were inoculated against:

Hepatitis (Gamma-golbulin serum)
Typhoid
Yellow fever
Tetanus
Polio

Photographic Report

All members of the Expedition took their own cameras and in some cases one or more extra lenses. Where possible, non standard lenses were shared to reduce weight. 'Camera-Care' cases were used exclusively and proved a worthwhile investment, surviving a 100ft fall as well as many tropical downpours.

The camera bodies were of various makes and all stood up well to the harsh treatment they received. I would recommend, apart from a standard lens, a 28mm wide angle lens for general mountain photography and for some of the most spectacular shots, a 70-200mm zoom, although this can be rather bulky and heavy. A good combination may be a 28mm and 70-200, leaving the standard lens at home. For mountain climbing and walking, the most useful piece of equipment is a compact 35mm camera which can fit into a jacket pocket. A small tripod is a useful extra, try converting an ice axe.

Only two filters are really essential; a U.V. (or skylight) filter for colour and a yellow filter for black and white. A polarizing filter was also very useful to reduce glare from snow and to give deep blue skies which can really make some pictures.

Kodak film was used exclusively. Kodachrome 64 was the most widely used, giving consistently good results. Photography in the jungle requires a faster film and we chose Ektachrome 200 or 400. The colours were dull in comparison with the Kodachrome 64. For black and white photography Plus-X pan film was taken which was disappointingly grainy when enlarged to 5x7 (inches) and bigger.

When visiting a foreign country, take all your film with you, in some countries you will not be able to buy your favourite film e.g. Kodachrome is not available in Ecuador. Also when it can be bought, it is often twice the price.

In general, we are pleased with the photographs we took. They shall certainly make an excellent record of our expedition.

STATEMENT OF ACCOUNTS

Income

Personal contributions:		3,000
Donations:		2,800
Mount Everest Foundation	(350)	
Cambridge University Engineers Assc..	(300)	
Gilchrist Educational Trust	(250)	
Royal Geographical Society	(250)	
Cambridge Expeditions Fund	(200)	
Robinson Charitable Trust	(200)	
Others	(1,250)	
Sale of Equipment		138
Insurance claim		48
Interest		25
	Total	£6,011

Expenditure

Airfares and Airport taxes		2,852
Equipment		1,110
Food		540
Insurance		510
Internal Transport		190
Administration		180
Accommodation		110
Guide		100
Films/Books/Maps		84
Medical equipment		72
National Park Entrance Fees		45
C.E.C. Capitation Fees		30
Estimated cost of Final Report		160
	Total	£5,983

Projected surplus of £28 will be given to an expeditions fund if it is indeed remaining when the accounts are closed.

Acknowledgements

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The Mount Everest Foundation,
Cambridge University Engineers Association,
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The Robinson Charitable Trust,
The Cambridge Expeditions Fund,
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Reigate Grammar School,
St. Regis International,
Sir Walter Verco,
The Department of Earth Sciences,
Sir Donald Baron,
Charles Wells Ltd.,
Robinson College,
Pye Telecommunications Ltd.,
The Godolphin and Latymer School,
H.D.H. Wills 1965 Charitable Trust,
Gill and Dufus,
Douglas Heath Eves Charitable Trust,
Walsall Municipal Charities,
Welconstruct Trust,
Foxboro (G.B.) Ltd.,
Ferranti p.l.c. (Scottish Group)
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Sprayway Ltd.,
Europa Sport (London) Ltd.,
Tog 24,
Mountain Technology,
Camera Care Systems,
Kodak,
Vango (Scotland) Ltd.,
Varta Ltd.,
Wonder (U.K.) Portable Power Ltd.,
Almay Cosmetics,
W.B. Pharmaceuticals Ltd.,
Chefaro Propietaries Ltd.,
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