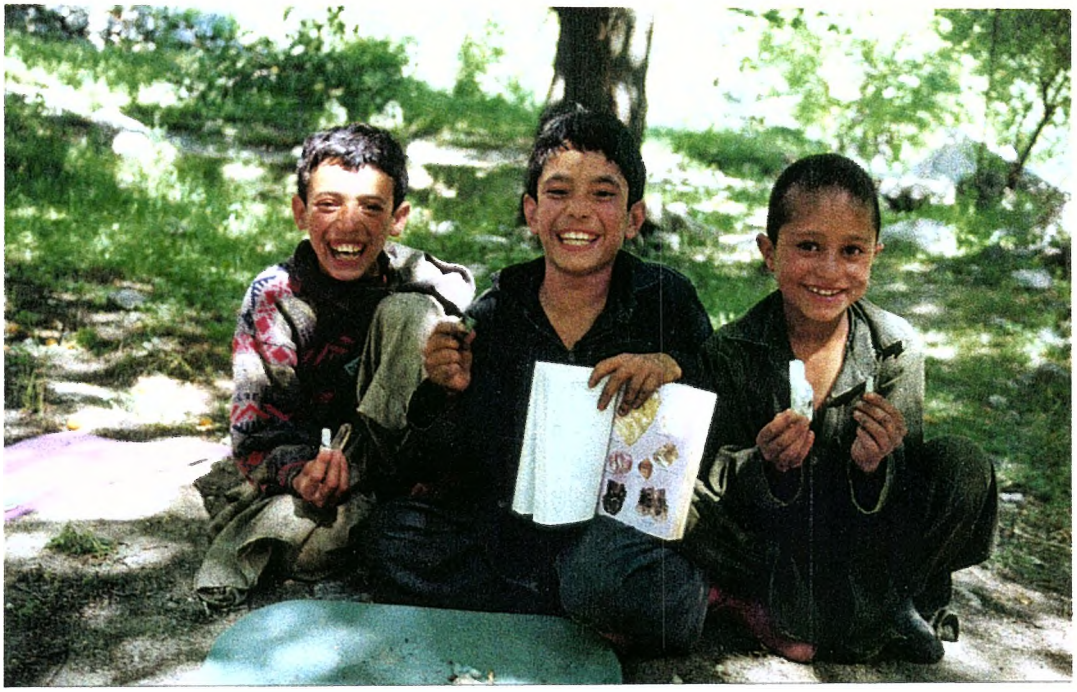
DURHAM UNIVERSITY KARAKORAM EXPEDITION 1995



frontispiece

Children from Jutial Village enjoying a mineralogy lesson

CONTENTS

EXPEDITION APPENDIX J.FREEMAN

ACKNOWLEDGEMENTS

This expedition would not have been possible without the very generous support of numerous sponsors. Firstly, we would like to thank the Royal Geographical Society and the Expedition Advisory Centre, whose support and advice contributed significantly to the success of this expedition. In particular we acknowledge the generosity of the Rolex Watch Company in making funds available to the Royal Geographical Society from which we benefited. We were also fortunate to receive the support of several other trust funds; the Albert Rickett Charitable Trust, the Foreign School Society Fund, the Gilchrist Educational Trust, the Mount Everest Foundation and St. Johns College, Durham. The University of Durham also provided invaluable advice through the Committee on University Expeditions and funds from the University Fund.

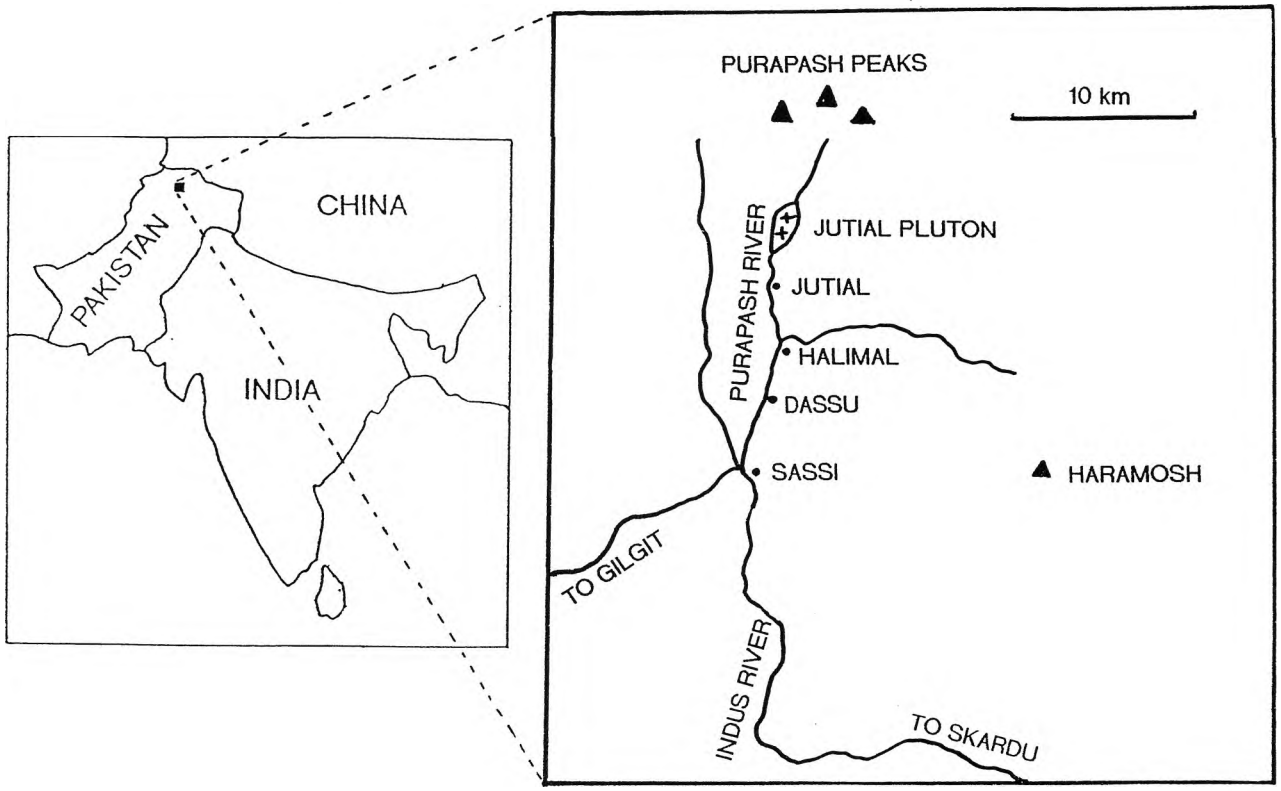
The initial inspiration for the expedition was provided by the leaders of the 1992 Durham University Expedition to the Karakoram, Mike Curtis and Mark Wharton. Their enthusiasm and advice at all stages of this expedition kept us going throughout the long hours of pre-expedition preparation. We also relied heavily on the advice of academics from several institutions, particularly Dr. R. Butler from Leeds University and Dr. N. Harris from the Open University. Drs. Sally Gibson and John Reavy were kind enough to supply us with references for several trust funds, which must have been far more glowing than we deserved. Medical advice and supplies were kindly supplied by Nurse Cramb of the University Health Centre and the St. Johns Ambulance.

Jon Freeman
Durham, 1996

INTRODUCTION

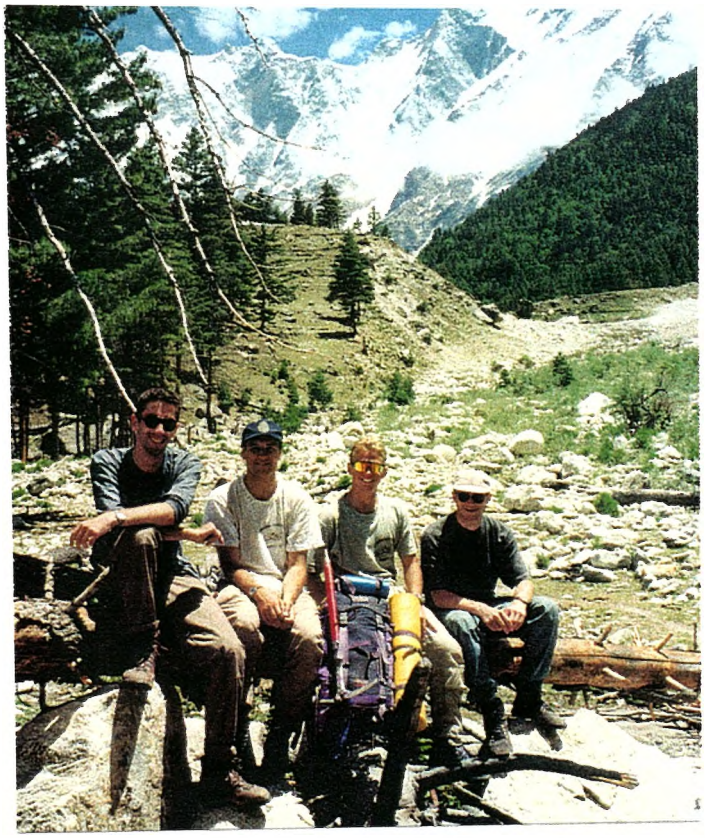
This report describes the organisation and scientific results of the Durham University Karakoram Expedition 1995. The aim of the expedition was to study the geological evolution of the Nanga-Parbat Syntaxis, a unique structure in the Himalayan mountain belt, located in the Karakoram Mountains, N.E.Pakistan. Unfortunately, due the inaccessibility of the outcrop in the field area, a problem which was unforeseen by either ourselves or our expedition advisers prior to the expedition, we could not carry out this field study by detailed, regional mapping, as we had originally intended. However, we did find that an igneous body exposed in the study area (the Jutial Pluton), which had only been given a cursory examination in previous studies, contained a wealth of fabric information which we could use to study the evolution of the syntaxis from a different perspective. This igneous body became the focus of our scientific investigations.

The results of the expedition are presented in three sections. The Expedition Report describes the organisation and execution of the project. The Scientific Report describes the results of our field study on the Jutial Pluton. Finally, the Expedition Appendix gives detailed information about the logistical aspects of the expedition. The map below shows the location of the field area and of villages, rivers etc. mentioned in the report.



EXPEDITION REPORT

Recently, several expeditions from the Department of Geological Sciences, Durham University have visited the Karakoram Mountains, N.E. Pakistan. Inspired by these previous expeditions, Jon Freeman decided to organise an expedition for the summer of 1995. With the help of Mike Curtis and Mark Wharton, the leaders of the 1992 expedition, and Robert Butler at Leeds University, who is a prominent researcher in the region, Jon devised a field project which aimed to build on the work of the previous expeditions, using field techniques which have been developed at Durham. One of the other postgraduates in the department at Durham, John 'Jipper' Jaques, has spent the last five years using and developing these new methods of field analysis and joined the team to co-ordinate the scientific side of the expedition. To complete the team, Jon decided to recruit a couple of undergraduates, to help organise the logistics and take field measurements, and approached Dante and myself (Simon) to see if we were interested. An opportunity to get involved in some exciting geology was clearly not to be missed and we signed on the dotted line immediately.



The team, (from l to r) Jon Freeman, Simon Williams, Dante Mantella and John Jacques.

FROM DURHAM TO THE HIMALAYAS

After nine months hard work fund-raising, we had sufficient funds to start booking flights, and it finally started to feel as though we really were going to get out to the Himalayas. Organising our flights out to Pakistan was straight forward. We decided to avoid the cheapest option of Aeroflot, after one of their planes had dropped out of the sky a few weeks earlier. Of the other carriers on the route, only Pakistan International Airlines offered the attractive bonus of 20 kg free excess baggage per person on the outward flight. This eliminated the potential bureaucratic nightmare of freighting our food and equipment out to Pakistan separately, and ensured that they received our business.

Despite trying our best to take only 'essential' gear we still managed to leave for Manchester Airport with 135kg of expedition and personal gear. We arrived at the airport early to avoid the queues, and we were unexpectedly upgraded to first class. The eight hour flight passed quickly as we made the most of the comforts of first class travel. However, this only served to heighten the culture shock as we stepped off the plane at Islamabad to be greeted by temperatures in the high 30's and steam-room humidities. None of us had been entirely sure what to expect, but the dilapidated state of the airport arrivals hall certainly came as a surprise after leaving the plush new terminal at Manchester. Our rucksacks and kit boxes were the last to be off-loaded, we piled them all onto trolleys and headed for the exit.

We hadn't taken two steps into Pakistan before one trolley disappeared off in one direction and the other in another - we were swarmed by porters and would-be taxi drivers. Somehow both trolleys eventually met in the crowded taxi park, and despite the attentions of half a dozen taxi drivers, each of which allegedly had the best and cheapest taxi in Pakistan, we managed to squeeze into one small vehicle which was well past its retirement age. The driver didn't seem to mind that the cars' suspension was grounding and we negotiated a fare which we subsequently discovered was only four times the typical rate - you learn quickly.

Before leaving the U.K. Jon had spent a fruitless afternoon on the phone trying to book accommodation for our first night in Islamabad. But the satellite delay and language barrier conspired to transform each call into a scene from Monty Python, so we were dependent upon the Lonely Planet guidebooks' recommendations. We opted for the

middle-of-the-road New Kamran Hotel, situated in the central Saddar Bazaar district of Rawalpindi. It proved to be an excellent choice. All the major services were within walking distance and the hotel itself was clean and mercifully free of carnivorous creepy crawlies.

Our first orientation day was essentially quiet, as we acclimatised to the heat and the unfamiliar surroundings. We ate in nearby restaurants that had been cited in the Lonely Planet, imagining every meal would strike us down with some unmentionable stomach complaint.

The next few days were spent visiting the British High Commission to register, changing money, sorting out transport to Gilgit and buying more food. Dante also made a start on his attempt to catch the greatest number of illnesses in an expedition, and spent the first few days in bed suffering from the heat and humidity.

We bought the majority of our remaining food at Esa Jees, a well known expedition supplier in Saddar Bazaar. Having all the extra food created a space problem, and we were forced to look for suitable containers to pack it into for the trek out to the field area. Ideally we wanted a couple of the blue 'expedition' drums, which we had seen lashed to the top of every bus travelling in the direction of the mountains since we had been in 'Pindi. We figured Rajah Bazaar would be a good place to look for them, and we wandered for hours taking in the sights, sounds and smells of the bazaar, but without any sign of a plastic drum shop. Asking directions was limited to sign language and pigeon English, none of us displaying any linguistic flair what-so-ever. However, with enthusiasm fading fast, we finally stumbled upon the plastic drum shop and purchased two large drums.

By this stage we had assembled a great deal of equipment, and the chance of getting all to Gilgit in one piece on the public bus service seemed fairly remote. Bearing this in mind, we decided that it would be much safer and simpler to hire our own minibus. The most professional looking operator was Pakistan Tours, but they were asking an extortionate sum for the sixteen hour drive to Gilgit. We also tried the Lonely Planets recommendation, Saeed Wagon services of Rajar Bazaar - but we had a few reservations. Firstly, the driver looked to be about seventeen, which didn't fill us with confidence, and secondly we weren't able to see the vehicle because it was having a 'little service'. So we

decided to give them a wide berth and finally opted for the mid-priced Hunza Tours, located near Pir Wadhai bus station.

Our time in 'Pindi wasn't purely for organising the approaching journey, we also managed to find some local entertainment. On Thursday evening we popped into the Australian High Commission for their Australia Club Night. We were directed round to the back of the Commission and asked to sign in, once inside the grounds we were drawn toward one of the very few legal bars in Pakistan. As the night progressed the place came alive, filled with many different nationalities, all joined together by the drink that knows no boundaries - beer! It was certainly an unusual experience and the only Australian in the place seemed to be Simon.

We were due to leave for Gilgit the next day, and after developing a healthy scepticism for Pakistani time-keeping over the previous few days, we were amazed when the minibus turned up at the appointed hour - 5am. As we loaded up we noticed that there was something strangely familiar about the driver. He was the same one we had met and dismissed at Saeed Wagon Services!

We were looking forward to the drive along the famous Karakoram Highway, and it was a relief to be leaving the city behind. However, it soon became apparent that our initial feelings about the driver had been correct, as he began to drive more and more aggressively, taking huge risks as he overtook. As we progressed further into the foothills, landslides became as big a threat to our safety as the oncoming traffic, and we seemed to stop every five minutes to push the minibus through yet another sea of mud. Naturally this quashed our enjoyment of the scenery, as our eyes were all glued on the road ahead. The trip went from bad to worse, as the driver seemed to spend more time on the wrong side of the road than on the right . We tried, diplomatically at first, to get him to slow down, but he thought it was all a bit of a joke. After a few shouting matches he did drive slightly less recklessly, and we eventually arrived in Gilgit at 10.30 pm. We unloaded, paid the driver and vowed that we'd take the plane back to 'Pindi.

Further organisation was required in Gilgit. We split into pairs to complete our shopping and make enquires about hiring a jeep to get out to the field area. Most jeep owners didn't seem to know the village we were trying to get to, and none of them could comprehend why we wanted to go there. They tried to convince us that what we really wanted to do, was to go trekking from their village. The hire quotes ranged form Rs 800

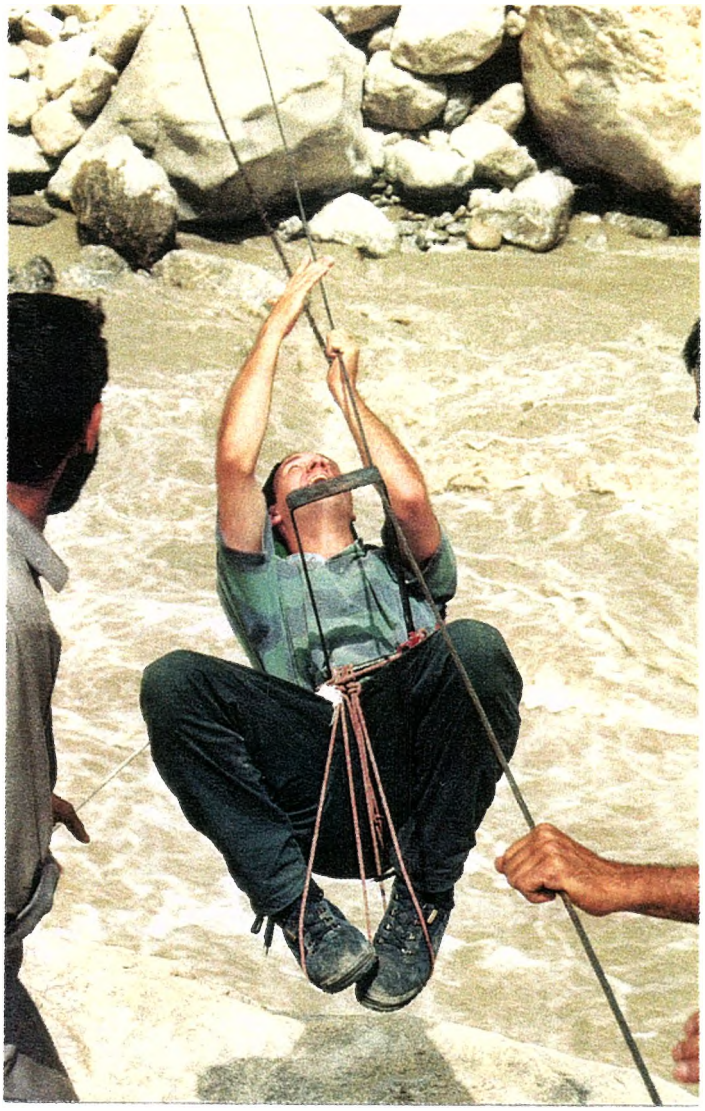
to 1,800, with everyone insisting that they had the best jeep in the whole of the Himalayas. We decided to opt for a driver who had been introduced to us by our hotel owner, because he at least spoke reasonable English, and his jeep looked as though it might have been serviced at least once or twice in its lifetime.

Making slow progress up the Karakoram Highway

After a hearty final breakfast in Gilgit we met up with our driver, who nearly had a heart attack when he saw the amount of gear we had. But with the aid of miles of rope, and a good deal of brute force, he managed to fit it all in the jeep. This time the drive was excellent. We stopped in villages on the way to take tea with the drivers friends - a ritual we were to get used to during our stay in Pakistan.

Eventually we left the sealed road and headed up a very steep track to the north. Four-wheel-drive engaged, we wound our way up the track which had been scratched out of the side of a mountain. The hair-pin bends were scary to look, at but it turned out to be even scarier to drive around them, as the hand brake on the jeep had failed years ago. The three point turns on each hair-pin corner were accomplished with a nifty bit of clutch control, and a few heart stopping moments.

The journey ended abruptly on the wrong side of the valley at Dassu bridge, which had disappeared during the snow melt earlier in the year. The bridge was in the process of being slowly rebuilt, but not in time to be of any use to us. In its place was a metal cable, suspended between two large boulders, a few meters above the raging Phurapash River. A metal bracket and a length of nylon rope, that you wouldn't even use to hang your washing out on at home, were kindly made available to us so that we could pull ourselves across the wire. Suddenly we wished that we had brought a harness and ropes with us from the UK.. The bridge builders came over to give us a hand and two hours later we were all safely across.



Crossing the Purapash River.

Jon and Dante headed into Dassu to find some porters, while Jipper and Simon looked after the gear, and pondered whether our Thomas Cook insurance covered us for suspending ourselves over raging torrents. Three hours later Jon and Dante returned with thirteen porters and the local policeman, who had decided that he was going to be in charge of our porterage - we were in no position to argue. It was approaching 5pm and we were keen to get moving to our first nights camp as quickly as possible. Displaying a complete lack of appreciation about local pay rates, we offered the porters Rs 200 per stage. The indecent haste with which they accepted the offer suggested that the last visitors to the area hadn't been so generous.

Despite hitting the wages jackpot, there were a few groans of discontent as the porters picked up the heaviest looking crates. The policeman complained that the loads were too heavy, and that more cash or more porters were required. This poor attempt to squeeze more cash out of us was quickly quashed by Jon bringing out the trusty expedition spring balance. On seeing that the loads were fair the porters dived for whichever load they thought was lightest, the result being the older, slower porters ended up with the largest loads. Finally we set off for and headed for Halimal, 4 km to the north.

The walking was hard going, the policeman taking us down to the rivers edge where we had to scramble along amongst huge boulders. Our map seemed to show some kind of track between Dassu and Halimal, but the policeman was adamant that this was the best route, so all we could do was struggle along in the wake of the porters, most of whom looked to be at least 40 years older than us. The walk to Halimal took three hours in all and it was pitch black by the time we had found somewhere to camp. Our spirits weren't lifted any further when we discovered the only water supply was so heavily choked with sediment, that we could barely force it through our filter. All-in-all this was not an auspicious start to the fieldwork.

We woke early after a restless night to discover that most of the porters had disappeared to find some breakfast. The porters that had remained around the camp watched us prepare for the day ahead, which was initially quite unnerving as none of us had been subject to such close scrutiny before. Eventually all the porters drifted back and we set off for our first intended field camp.

This time we took the sensible precaution of starting off infront of the porters and found the track which was marked on our map. Looking back down the valley, we could see

that the track had only been a few hundred metres uphill of our route the day before after all. It took less than two hours to reach the next village, Jutial, where the porters downed tools and refused to carry on any further up the valley. The policeman explained that porters from each village weren't allowed to carry loads any further up the valley than the next village. We had a feeling that the rules were being changed all the time, but we could do nothing but try and negotiate with a new group of porters. However, this proved to be even more difficult than hiring our first set. The main problem was that there were only six porters in the village, so each one was going to have to make the journey along each stage twice, and the cost of porterage would therefore double. Secondly, they refused to take us as far up the valley as we wanted to go, and they were estimating at least four days work just to get us another few kilometres up the valley.

A veiw up the Purapash Valley with the village of Halimal in the foreground, note the thick scree slopes uphill from the tree-line which marks the level of the track.

No amount of arguing was going to change their minds, we realised that moving the camp any further up the valley was going to seriously erode both the amount of time we could spend doing fieldwork, and our expedition finances. A quick look at the map convinced us that we could still complete the fieldwork if we camped where we were, we would just have to walk further each day than we had originally planned to. However, staying put

created a problem in itself as none of the villagers wanted us to camp in the village. But as we had come to appreciate, money talks, and we were able to hire a small campsite at the princely sum of £1 per day. The camp was well away from the main village and in the shade - it seemed too good to be true. Over a years planning had passed to reach this point, we set up camp, put the kettle on and began assessing the fieldwork ahead.

THE FIELDWORK

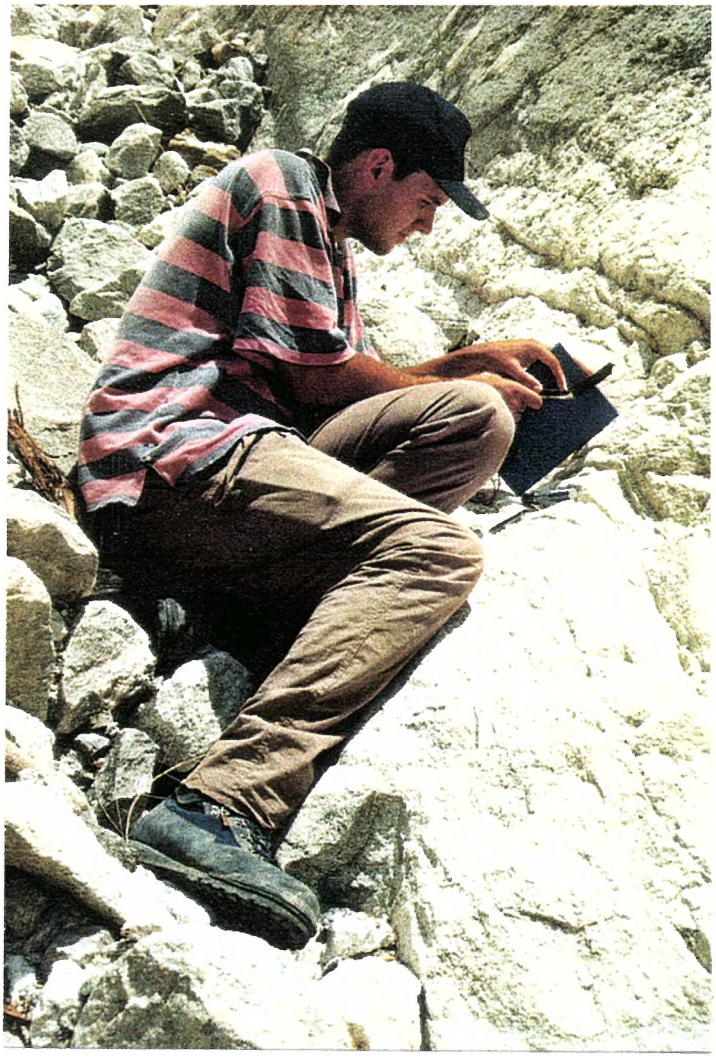
The area around Jutial was extremely dry, and the valley sides steep and scree covered. Our expedition advisors had suggested that we would have excellent exposure in which to carryout our detailed field mapping, however, it soon became apparent that the only decent exposure was inaccessible, at the top of the treacherous scree slopes. Obviously the safety of the team in such a remote location was paramount, and working on the scree slopes on a daily basis was out of the question. In the light of these limitations we decided to reassess our original field programme.

Fortunately, a small pluton outcropped in the valley only a kilometre or so from our camp. Our original, regional mapping was to have included a brief examination of the pluton. A quick reconnaissance of the pluton revealed that it was a far more complicated body than had been previously described in the literature. Exposure of the pluton was reasonably good, with abundant boulders in the valley floor from which we could carry out our lithological studies, and critical exposures in the valley sides were just about accessible with short scrambles up the screes. Another few days spent measuring fabrics in the pluton convinced us that an important geological story was being recorded by the intrusion, and that a detailed study of the pluton would provide an alterative field project.

A second important finding of our first few days of preliminary study, was that we were going to be fried alive in the narrow valleys if we continued working a normal 9 to 5 field day. So to avoid the heat, we decided to start work at 5 am and followed the locals example of spending the early afternoon snoozing in the shade, before spending another couple of hours working in the late afternoon. Despite a few moans and groans at the early start we settled into a routine fairly quickly, taking it in turns to get up even earlier to cook porridge for breakfast and put the kettle on.

Life around Jutail had its usual ups and downs. Fortunately, the locals turned out to be extremely friendly, depite the guidebooks warning that trekking groups passing through

the area had been hassled. For the most part we were usually embarrassed by their generosity, as they brought us an overwhelming daily supply of apricots. At first we welcomed this addition to our diet of dehydrated food. However, we soon discovered the purgative results of excessive apricot consumption, and we eventually had to undertake a recycling operation, putting the apricots back under the trees where they could be recollected by the locals. Because we were the first visitors to the area for several years our campsite became something of a tourist attraction for the locals, and its was rare for us to have a moments privacy after a low wall along the camp, was adopted as the grandstand from which our every move was observed.



Simon taking measurements of fabrics close to the contact of the Jutial Pluton.

Unfortunately, the local fly population turned out to be even friendlier than the villagers, and they managed to get themselves into absolutely everything. Even though we covered all the food with tea towels(which were boiled in salty water every day to try and keep them clean) while we prepared it, and kept all the plates and cutlery in the expedition drums when not in use, Simon still caught a virulent stomach bug and spent a few days doing the Pakistan Sprint to our toilet site.

Our biggest problem was obtaining a water supply. All the nearby streams were choked with sediment which made it impossible to filter the water, even after we had tried to remove some of the silt by running the water through fine gauze from the first aid kit.. Eventually, we found a marshy area half an hours walk form the camp, where we could squeeze out a water supply by using stones to divert the trickles of water on the surface into one reasonably sized trickle. Despite having a couple of large water containers with us, water collecting became a daily chore.

We only moved camp once during the fieldwork period, back down to Dassu, where we aimed to map some of the regional structures which might have controlled the intruision of the pluton at Jutial. This time there wasn't a shortage of porters in Jutial as every man and his dog wanted to help out. We only needed nine porters this time, and since we had got to know the geography of the valley considerably better during the fieldwork, we were able to get the men to agree to do the trip to Dassu in one day. We broke camp and incinerated all the flammable rubbish. The remaining rubbish was bagged up for the walkout and entrusted to one of the porters, who promptly tried to throw it into a nearby stream! We recovered the bag and decided the best bet was to carry it ourselves, much to the embarrassment of the porter.

Initially we made quick progress down the valley, using the road this time instead of being conned into following the longer, and slower, route along the river bank. Our quick progress was soon brought to a halt however, when we discovered a bridge over one of the side tributaries had been badly damaged by floods, caused by the previous days rain. Half the bridge was tilted precariously on its side, and the porters were none to keen to cross it. After our experience on the wire we weren't going to be out off by anything so trivial, so Dante and Jipper crossed the bridge to demonstrate its stability. This didn't impress the porters in the slightest, and they argued for a diversion up the tributary valley to the next village, where another bridge crossed the stream. Conveniently this would also involve an extra two days walking, and of course two days pay. After further

negotiations, supplies of cigarettes and team photo taking, we eventually convinced the guide it was safe enough to cross the bridge. One word from him and the porters were across the bridge in no time.

A further two hours walking brought us to Dassu where our guide showed us a suitable campsite. Dassu is a much larger village than Jutial and we drew far larger audiences. This was quite intimidating and forced us to keep someone at the camp at all times to supervise the gear. The atmosphere wasn't as relaxed as at Jutial and we were glad of the two days of heavy rain we experienced at Dassu, which not only kept the temperatures down but also discouraged the crowds of sightseers.

The usual crowd of sightseers at our camp in Jutial.

RETURNING HOME

The first leg of our journey home was in porter convoy from Dassu to the village of Sassi, on the Skardu to Gilgit road. Thankfully the bridge repairers at Dassu bridge had been hard at work while we had been further up the valley, and a temporary footbridge had been erected between the new bridge supports. This made the crossing considerable easier, but not much safer. We arrived back at the main road at midday and all that stood between us, hot showers, and soft beds in Gilgit, was 80 km of highway.

We had been told at Dassu that hiring a jeep at Sassi wasn't going to be a problem. It didn't take us long to realise that this was another over-optimistic Himalayan promise, and in fact no jeep appeared to exist in Sassi at all. We were quite alarmed at this situation, especially since we were about to be dumped by the porters beside the main road, with all our gear and no definite lift that day. We withheld payment from the porters until we found a safe campsite, where we could spend the night if need be, and after receiving their payment they left one by one. Eventually just our guide and a few curious children remained.

The guide kindly offered to stay with us while we tried to hitch a lift back to Gilgit, and negotiate with drivers on our behalf. It didn't take us long to realise that this wasn't the busiest road in the world, and our chances of making it back to Gilgit that day were beginning to look fairly slim. Most of the jeeps that passed were heavily laden with expeditions returning from Skardu, and all the minibuses were full. Eventually a minibus with one spare seat arrived, and we decided to send Dante back to Gilgit where he could organise a jeep to pick us up if we failed to make it back that night.

Fortunately, we didn't need to set up camp, for after another hours wait a Landcruiser with plenty of space in the back came along.. The driver wanted Rs 1500 to take us back to Gilgit, well over the going rate, but we were past caring and took the offer. It was an amazing ride, sitting in the open air in the back of the jeep, with terrific views over the massif and down the Indus valley towards Nanga-Parbat in the sunset.

SCIENTIFIC REPORT

THE JUTIAL PLUTON : MULTIPLE SHEETING INTO AN LOW-ANGLE REVERSE FAULTS AND ASSOCIATED CONJUGATE SHEARS; IMPLICATIONS FOR LATE CENOZOIC TECTONICS OF THE NANGA PARBAT MASSIF, NORTHERN PAKISTAN

INTRODUCTION AND REGIONAL SETTING

The Himalayan Mountain Belt marks the contact between two continental landmasses, the Indian Plate to the south and the Asian Plate to the north. Over the last 60 million years, movement of the Indian Plate northwards (in response to convection of the Earth's mantle) has resulted in the collision of the two continental plates, creating a wide zone of deformation. Within this zone, the rocks of the Indian Plate are being compressed and shortened, and have responded to this deformation by fracturing along a series of northward dipping, shallow angle faults (Fig. 1). These faults are major, crustal scale, structures which carry fragments of small crustal plates, which were trapped between the two main landmasses, and slithers of Indian Plate southwards onto the main Indian Plate.

On a large scale these major faults are arcuate in plan view (Fig. 2). However, at the north-western physiographic termination of the Himalayan Mountain Belt in Northern Pakistan, the regular pattern of these faults is disturbed by a series of very large, crustal scale folds. These folds are the largest known structures of their kind in the world, and because of their unique position in the Himalayan deformation zone, they have been the focus of considerable geological research.

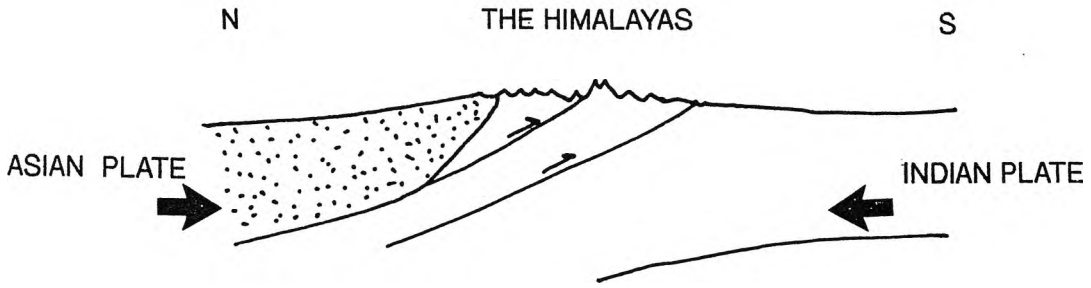


Figure 1. A simplified cross-section showing the collision of the Asian and Indian Plates, half arrows mark the major faults.

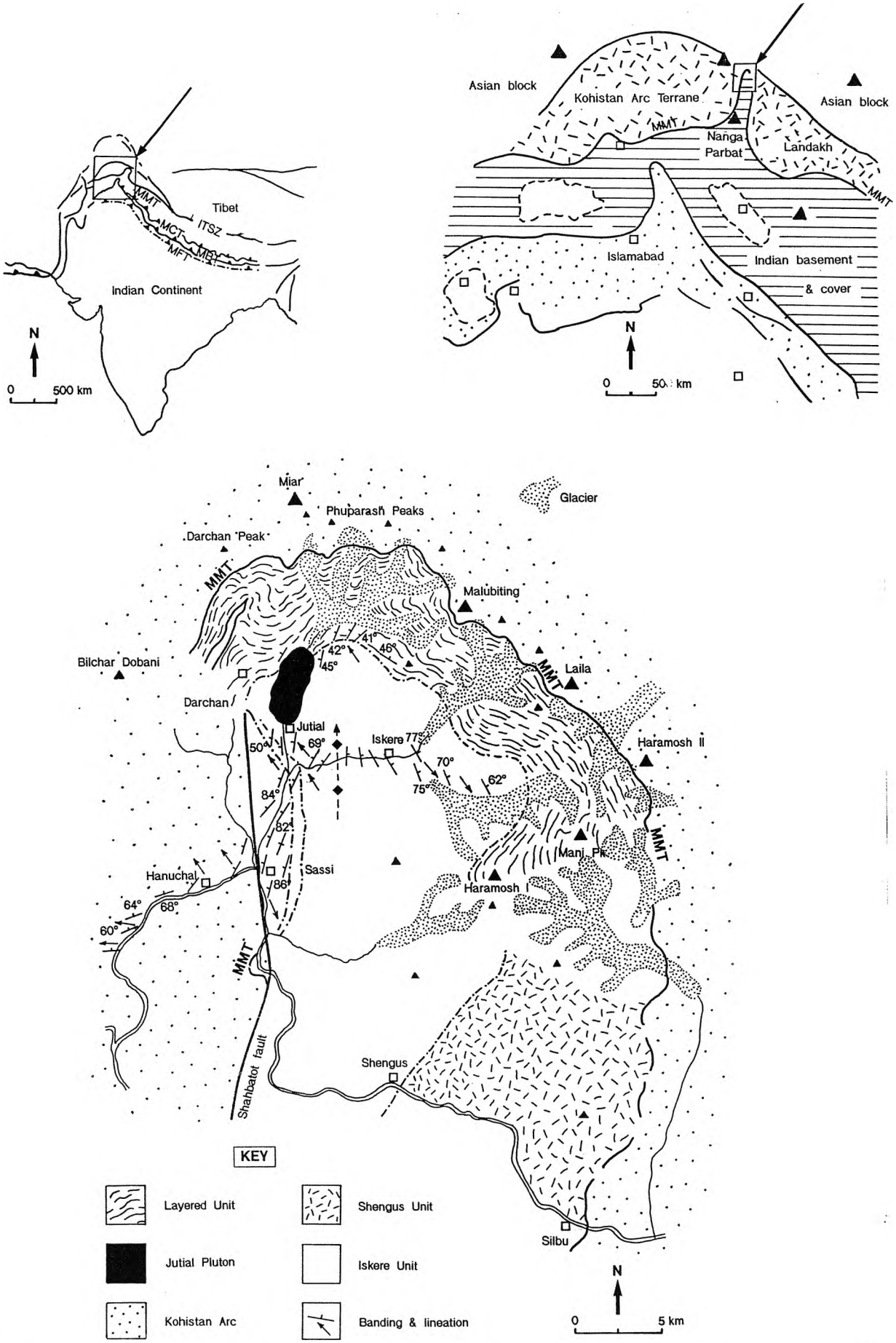


Figure 2. Location and regional geology maps of the N.W.Himalayas showing the position of major tectonic structures. A generalised sketch map of the Nanga-Parbat massif, largely after Butler et al, 1992, banding and lineation data from our study.

The northern-most fold forms the core of the Nanga Parbat Massif (Fig. 2), which is the fastest rising part of the Himalayas at the present day (Zeitler *et al.* 1989) and exposes the northernmost outcrop of Indian continental crust. The massif is composed of high grade gneisses which have been intruded by a small plutonic body, the Jutial Pluton, which is the focus of this research project.

THE NANGA PARBAT MASSIF

The unique structure of the Nanga Parbat Massif has been attributed to a number of important facts:

(i) It is the only part of the collision zone in which the contact between the Indian and Asian plates is perpendicular to the direction of collision (Butler *et al.* 1989).
(ii) It represents part of the plate boundary which experiences a transitional change from south-directed convergence in the Himalaya to left translation along the Chaman transform zone (Chamberlain *et al.* 1989).
(iii) The zone reflects the original collision and subsequent suturing of India and Asia.

The massif also forms the northern-most outcrop of the Indian continental basement and is particularly important as it is the fastest rising part of the orogenic belt along the whole Himalayan range (Zeitler *et al.*, 1989). All these points indicate that this zone may hold important information about the nature of the collision, and subsequent suturing, of the India and Asia Plates, and so has become an important element in plate tectonic theories.

LITHOTECTONIC UNITS WITHIN THE NANGA PARBAT MASSIF

The gneisses which form the Nanga Parbat Massif have been divided by previous workers into three units; the Shengus Unit, the Iskere Unit and the Layered Unit (Fig. 2).

The Shengus Unit is not exposed in the study area, but has been described by Madin *et al.*. (1989) as a paragneiss consisting of fine grained, finely layered, amphibolite grade pelitic, psammitic and calc-silicate gneisses with subordinate amphibolites. The protoliths are inferred to be a sequence of arkosic sandstones, shales, marls, greywackes and limestones. U-Pb zircon age dating of these gniesses (Zeitler *et al.*. 1989) suggests that they are between 400 and 500 million years old.

The structurally higher Iskere Unit forms the majority of the exposure in the massif and is the country rock into which the Jutial Pluton was intruded. The unit consists of amphibolite-grade biotite gneisses containing intercalculations of metasediments (particularly biotite-schist and subsidiary calc-silicates) and amphibolite units. The protoliths of these gneisses have been interpreted as a sequence of arkosic and greywacke sandstones, interbedded with minor limestones which were intruded by a significant component of plutonic material of intermediate composition (Madin *et al.*. 1989). U-Pb zircon age dating of these gneisses (Zeitler *et al.*. 1989) suggests that they are approximately 1850 million years old, considerably older than the Shegnus Gneisses.

The Layered Unit forms the base of the Phuparash Peaks (Plate 1), located at the northern extreme of the field area. The unit is inaccessible across the Phupasrash glacier but was observed to consist of 100 m scale alternations of gneisses with numerous sill-like bodies of granite. This unit is clearly distinct from the Iskere and Shengus gneisses

Plate 1. The Phuparash Peaks

All these units have undergone substantial deformation by both Himalayan and probably pre-Himalayan tectonics and have subsequently been cross-cut by a suite of leucogranite and pegmatite dykes and sheets. These intrusives have been interpreted as the stockwork to a significant crustal-melt body, the Jutial leucogranite (Butler *et al.*. 1992). Located within the northern region of the massif, this plutonic mass occupies an area of at least 4 km by 3 km, making it significantly larger than other known leucogranites in the western Himalayas.

THE STRUCTURAL DEVELOPMENT OF THE NANGA PARBAT MASSIF

The Nanga Parbat Massif is defined by both internal fabrics, and the overall geometry of the enveloping Kohistan-India contact the Main Mantle Thrust (MMT).
Along the western margin of the massif early, ductile deformation fabrics are distinct from a late cataclastic faulting event which has modified the antiformal structure. The earlier deformational fabrics, which are associated the MMT, are extensively cross-cut by leucogranite sheets and pegmatites, which probably originate from the Jutial plutonic body. At Raikhot Bridge, approximately 45 km south of the Jutial leucogranite, pegmatite sheets show syntectonic relationships to deformational fabrics associated with the Liachar thrust (Butler *et al.*. 1989) which carries the Nanga Parbat Massif, including host gneisses and granite sheets, onto Quaternary gravels. They have textural, mineralogical and geochemical characteristics similar to the pegmatite sheets of the Jutial granite and so are believed to have been derived from the same source magma. Granite sheets within the hanging wall of the Raikhot thrust have been zircon dated, giving values of 2-8 Ma (Zeitler & Chamberlain 1991), indicating very recent anatexis. As stated by Butler *et al.*. (1992), peak metamorphism in the footwall to the MMT may be represented geologically by the production of small volumes of crustal melt leucogranites, such as the Jutial body. These pegmatites have been dated (Zeitler & Chamberlain 1991), giving a range between 2.3 and 7 Ma for the veins of zircon, with core ages of c. 1800 Ma, suggesting very recent anatexis of a Proterozoic basement. If the Raikhot pegmatites and Jutial body are coeval, their emplacement marks the youngest known phase of crustal anatexis in the Himalayan chain.

We seek to establish whether a detailed study of the distribution of the leucogranite sheets, the internal deformational characteristics of the Jutial pluton and associated country rock deformation, would provide information on the distribution and consequential interaction of tectonic-related strain fields during granite emplacement; possibly shedding light on the possible tectonic controls operating within that region

at that current time, which also controlled the structural evolution of the massif. We also wish to establish whether the Jutial pluton and associated leucogranite sheets are composed of a number of individual intrusive phases and events, which are distinct in terms of: (i) mineralogy and textural characteristics; (ii) relative time of emplacement; (iii) geometrical and internal structural features; and (iv) overall emplacement dynamics and their influence on deformation of the surrounding country rock. Syntectonic relationships established during such a study of pluton construction and leucogranite sheet intrusion, may ultimately provide invaluable information on the way the massif was deforming during their emplacement.

THE JUTIAL PLUTON AND ASSOCIATED LEUCOGRANITES

The Jutial pluton is a small, irregularly shaped, ill-defined mass of leucogranite (fig.3.). It is located within the north-western part of the massif, exposed within the side-walls of the Phuparash valley, and its long-axis essentially extends from the village of Jutial up to the base of the Phuparash peaks, i.e. the head of the Phuparash valley. Around the periphery of the mass is a zone of varying width (20-50 m) of leucogranite sheets and irregular blocks of varying sizes of host material (Iskere Gneiss). Within this zone of intricate intrusion, the size of the blocks, in general, progressively decrease away from the pluton margin. This is commensurate with a progressive increase in the width of the leucogranite sheets, which eventually cross-cut the Iskere gneiss (outside this zone) without any substantial displacement and rotation of the host. The predominant intrusive phase within the main mass of the Jutial body is referred to here as the 'main Jutial facies', with mineralogically and texturally distinct leucogranite sheets and dykes, which occur outside the pluton collectively referred to as the 'marginal leucogranites'. A number of distinct intrusive phases have been recognised, in terms of mineralogy, textural and internal structural features, and overall emplacement characteristics.

A broad intrusive sequence has been tentatively established for the intrusive phases both within and outside the Jutial body, however, there are many relatively minor intrusive episodes, often possessing similar lithological and textural characteristics to earlier intrusive events, which will not be discussed.

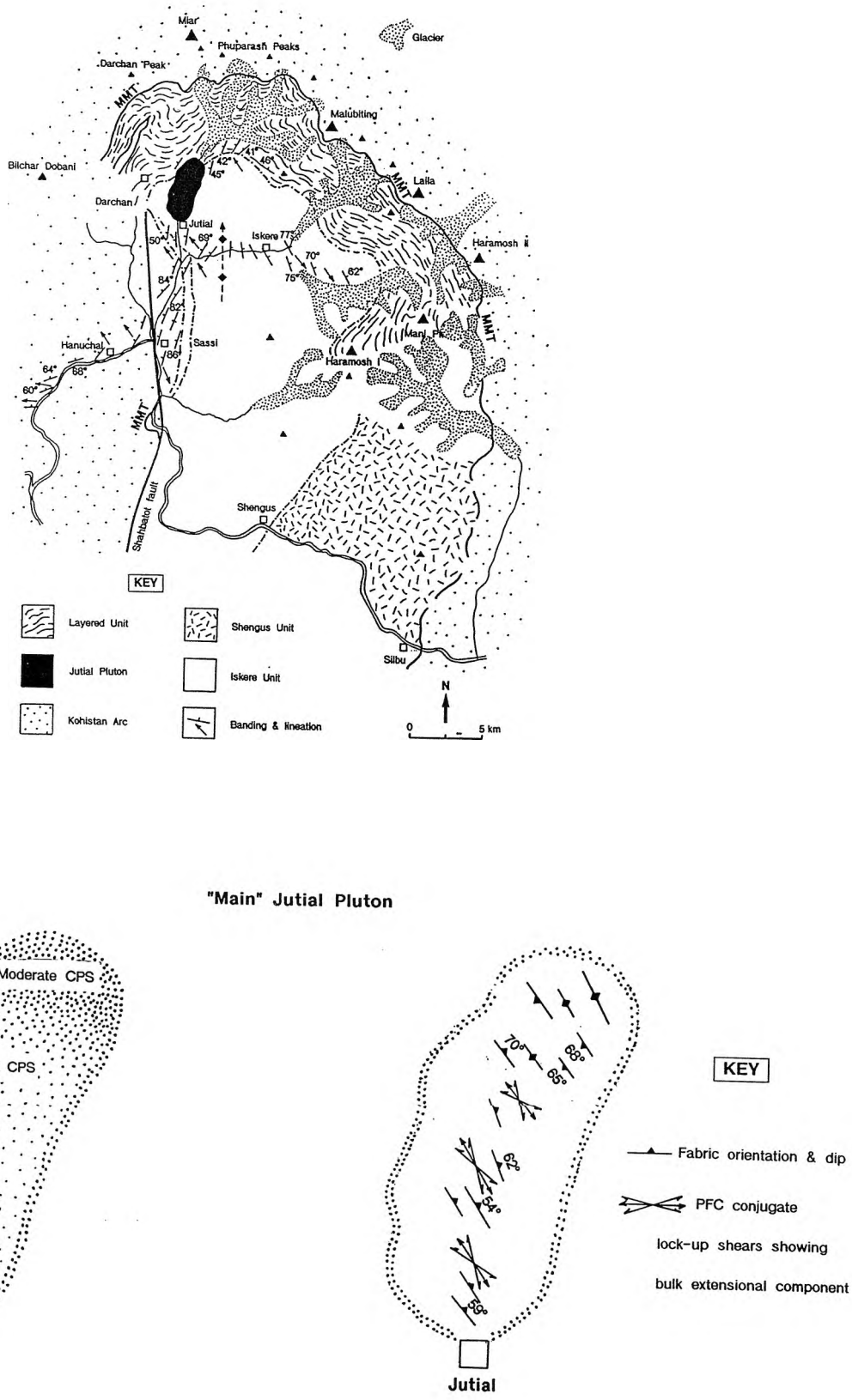


Figure 3. Fabric type distribution and PFC conjugate lock-up shears throughout the Jutial Pluton.

THE MAIN JUTIAL FACIES -Petrography

The rocks of the main Jutial plutonic mass are dominated by medium- to coarse-grained (2-5 mm), two-mica, tourmaline-bearing leucogranites (Plate 2). The 'main Jutial facies' is essentially equigranular and composed of equal amounts of oligoclase (30-35 %), quartz (27-30 %) and microperthite (25-30 %), and smaller percentages of biotite (5-13 %), muscovite (2-10 %) and skeletal tourmaline (up to 5 %). Common accessory minerals include zircon and apatite, together with the alteration products chlorite and secondary muscovite.

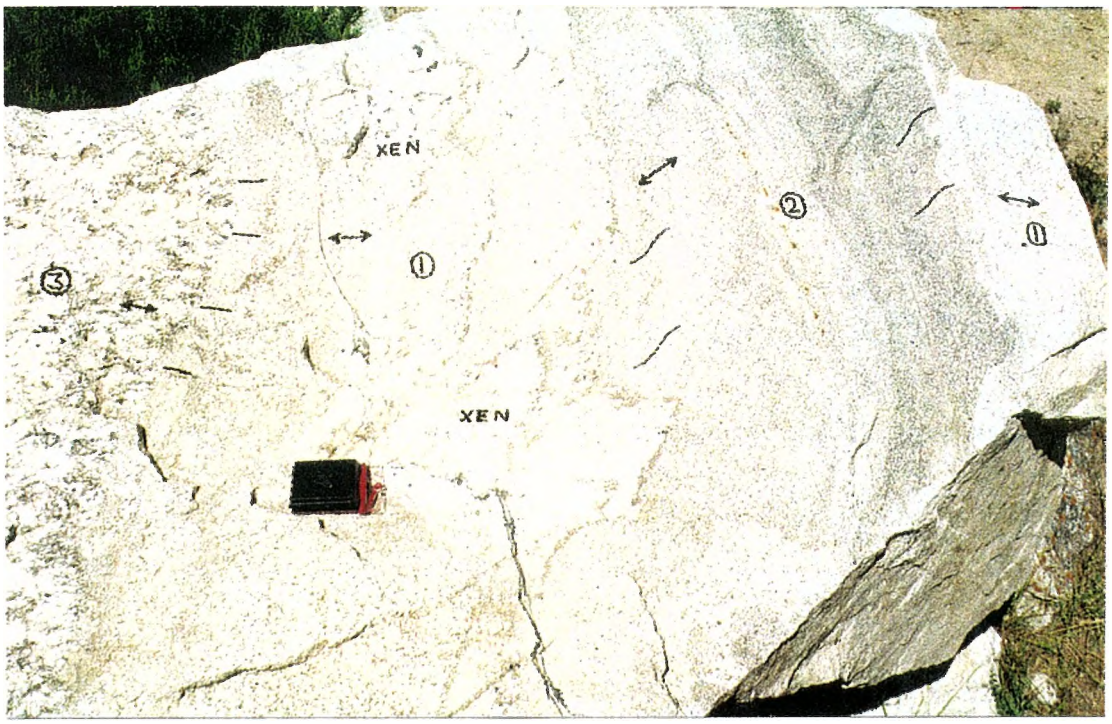


Plate 2. Lithological variation in the Jutial Pluton, black lines show fabric trajectories.

THE MAIN JUTIAL FACIES -Deformational fabrics

Pre-full crystallisation (PFC) fabrics:

Penetrative, generally moderately-inclined deformation fabrics of moderate intensity occur throughout the main Jutial body. In outcrop or hand-specimen the fabric is defined by the preferred dimensional orientation of biotite laths, and to a lesser extent by the crude alignment of feldspar crystals (particularly oligoclase). With increasing fabric intensity there is an obvious planar anisotropy of these two phases, combined

with the alignment of muscovite and late stage perthite crystals. In areas of weak to moderate fabric development these individual mineral phases show little sign of internal ductile deformation processes, such as dislocation and creep, and interstitial crystals such as quartz and feldspar are basically non-aligned and show little evidence of internal deformation.

In thin section, the microstructural features of these rocks within these relatively low to moderate strain regions are characterised by: (i) well-aligned, undeformed, elongate biotite laths (up to 0.75 mm in length); (ii) the crude alignment of undeformed plagioclase crystals (2-4 mm in length); and (iii) non-aligned groundmass crystals (particularly quartz) with equant, subhedral forms and showing only minor amounts of ductile lattice dissolution. These relationships are considered to have formed by the imposition of strain during crystallisation and deformation ceased before full crystallisation. These fabrics can thus be termed "pre-full crystallisation" or PFC fabrics in the nomenclature of Hutton (1988).

Weak to moderate, high temperature crystal plastic strain (CPS) fabrics:

In parts of the main plutonic mass, this PFC fabric has been modified by deformation which continued for a relatively short period after all the mineral phases in the magma had fully crystallised. These crystal plastic strain or CPS fabrics (Hutton 1988) are generally weak to moderately developed, high temperature fabrics which are probably formed as a result of deformation continuing into the solid state regime, as the overprinting fabric is co-planar to the pre-existing PFC fabric, enhancing its intensity. Microstructurally these fabrics are characterised by: (i) intensely aligned biotite crystals which may show a slight degree of distortion (bent or kinked crystals); (ii) plagioclase and alkali feldspar show moderate to good alignment and are dominantly undeformed. However, in areas which experienced a slightly larger component of down-temperature solid-state deformation, plagioclase crystals may show slight internal deformation in the form of slightly bent compositional planes and the margins of the crystals may be somewhat more irregular, and alkali feldspar may have undergone alteration by exsolution, producing microperthite; (iii) quartz occurs as an interstitial phase, and is the most susceptible essential mineral to crystal plastic strain deformation within the 'main Jutial facies'. It tends to develop strained undulose extinction, become elongate and flattened, and with increasing strain magnitude and/or continued down-temperature deformation it often forms polycrystalline lenses which often help to define the orientation of the CPS fabric.

Weak to moderate, high temperature CPS fabrics commonly occur within localised zones (generally < 5 cm in width) at the chilled contact of the leucogranite sheets; indicating as subsequent sheets intruded they induced a component of solid state strain deformation into the completely crystallised parts of the earlier sheets.

Moderate to intensely developed, high/moderate temperature crystal plastic strain (CPS) fabrics:

These fabrics are essentially confined to the north-eastern part of the complex (head of the Phuparash Valley) and appear to increase in both intensity and down-temperature solid state deformation towards the periphery of the pluton mass. As with other parts of the complex which experienced CPS deformation, the resultant fabric appears to be co-planar to earlier formed PFC fabrics, possibly indicating that the imposition of strain continued through the rheological critical melt percentag and into the solid state regime as the temperature was progressively lowering.

These fabrics are characterised by the following microstructural features: (i) biotite laths show clear evidence of internal ductile deformation in the form of kinked and bent crystals, often wrapped around feldspar crystals forming swathes which define the CPS fabric; (ii) plagioclase and alkali feldspar phenocrysts show distinct rounding due to deformation, resulting in subhedral crystal shapes. Many of the plagioclase crystals have undergone recrystallisation of their margins and subgraining, and the development of deformation lamellae; and (ii) quartz tends to be highly strained, elongate and many form ribbons. With the most intense high/moderate temperature CPS fabrics, biotite tends to form stringers which wrap themselves around the stronger minerals (feldspar and quartz), interstitial feldspar and quartz have undergone dynamic recrystallisation and dissolution forming finer-grained elongate aggregates, which together with ribboned quartz form folia. The folia define the fabric trend and can be used to determine shear sense, often forming a crude extensional crenulation cleavage (asymmetric S-C fabric).

Weak to moderately developed, low temperature CPS fabrics:

These fabrics predominantly occur within the north-eastern part of the pluton, where strain has been heterogeneously focused into discrete zones (generally < 20 cm wide) of shear, leading to the formation of an anastomosing "gneissic" CPS fabric, which completely obliterates the earlier, pre-existing PFC.

Throughout the whole plutonic body, continued deformation and/or reactivation along low angle reverse faults has resulted in the complex being deformed by a network of late stage, low temperature shear zones and brittle faults (ranging from a few cm's to metres in length). Cataclasites and less commonly, planar mylonites are extensively developed. Well developed stretching lineations, striations and shear fibres are associated more commonly with the km scale low angle reverse faults, but many also occur, and provide shear sense information, on metre scale, second order synthetic and antithetic faults (see below).

THE MAIN JUTIAL FACIES -Internal Structure

As shown by Figure 3 the predominant fabric trends approximately 150^0 - 160^0, subparallel to multiple leucogranite sheets which constitute a large percentage of the main body. As discussed above these contact parallel fabrics occur as both PFC and CPS fabrics, with a progressive increase in solid state deformation generally occuring towards the northeast of the body. Chilled contact relationships between sheets has been observed at a number of localities, and generally suggest that (i) the sheets have preferentially intruded from the southwest to the northeast; (ii) the sheets are on average 1.5 to 2m thick; and (iii) the sheets trend NNW-SSE, dipping 50^0-70^0 towards the ENE, steepening to the vertical in the northeastern part of the body (see Figure 3).

MARGINAL LEUCOGRANITE SHEETS AND DYKES

Two distinct marginal facies have been recognised; (i) a two-mica, coarse to megacrystically grained, leucogranite (facies A, Plate 3) and (ii) a tourmaline bearing, muscovite rich, coarse to megacrystically grained, leucogranite (facies B). Between these two end-member types, an extremely diverse range of compositions are found, see Plate .

Within the central part of the body, the PFC fabric has been extensively modified by PFC lock-up shears (Hutton and Ingram 1992, Figure 3). These PFC shears often occur as a conjugate arrangement showing bulk extension parallel to the predominant fabric direction. Continued down-temperature deformation has often resulted in the localisation of crystal plastic strain along these discrete shears, with many becoming melt-filled by later, facies A, leucogranite sheets.

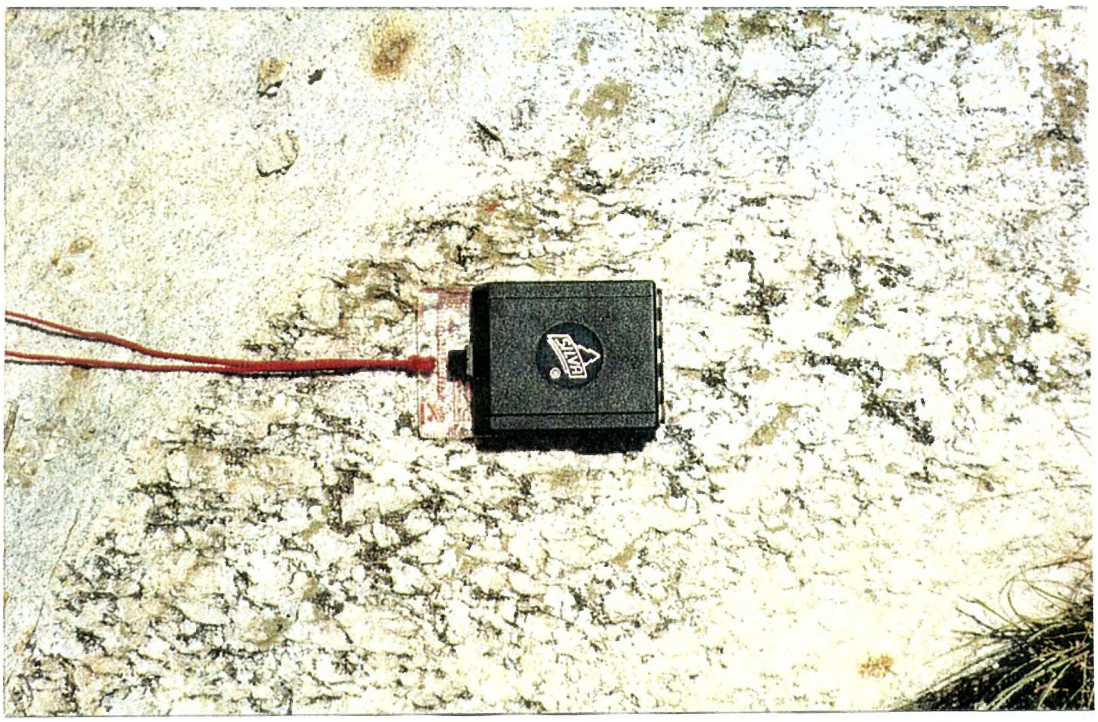


Plate 3. Contact between Facies A (right hand side of the photo)
and the main Jutial Pluton.

A clearly distinct phase of leucogranite sheets (facies B), cross-cuts both the 150^0 - 160^0 sheets of the main plutonic body and the melt-filled shears. These sheets are usually less than 2m wide and generally trend ENE-WSW, perpendicular to the sheets forming the main plutonic body. This phase intruding after both the "main body" and the "melt-filled shears" had fully crystallised and undergone a significant amount of cooling. Contact relationships are always planar and sharp, and internally tourmaline crystallises perpendicular to the contacts. These tourmaline crystals also show extensive extension parallel to their long axes, providing evidence for intrusion of these sheets into normal dilational fractures. This is in contrast to the emplacement of earlier intrusive components, which have intruded into oblique, dilational, ductile shears.

In addition to these two phases, a large suite of late-stage, sub-horizontal leucogranite sheets occur throughout the area. Their relationship with facies A and B is uncertain.

COUNTRY ROCK DEFORMATION

The most significant structures associated with the Jutial Pluton are a series of low-angle, reverse faults which appear to have been active during its emplacement. These faults can be observed in the valley sides and may form part of the Raihkot / Shabatot fault system. These structures generally dip between 45^0 -20^0 towards the ENE. On a large scale the intrusion of the main sheets has clearly been controlled by these faults (Figure), and asymetric deformation of large (metre scale) gneissic xenolithic blocks within the sheets, shows that top to the WSW defomation along the faults was contemporanious with intrusion. Combined with this over-shear was a small but significant dextral component, clearly seen by the deflection of pre-existing banding within the host gneiss (Plate 4).

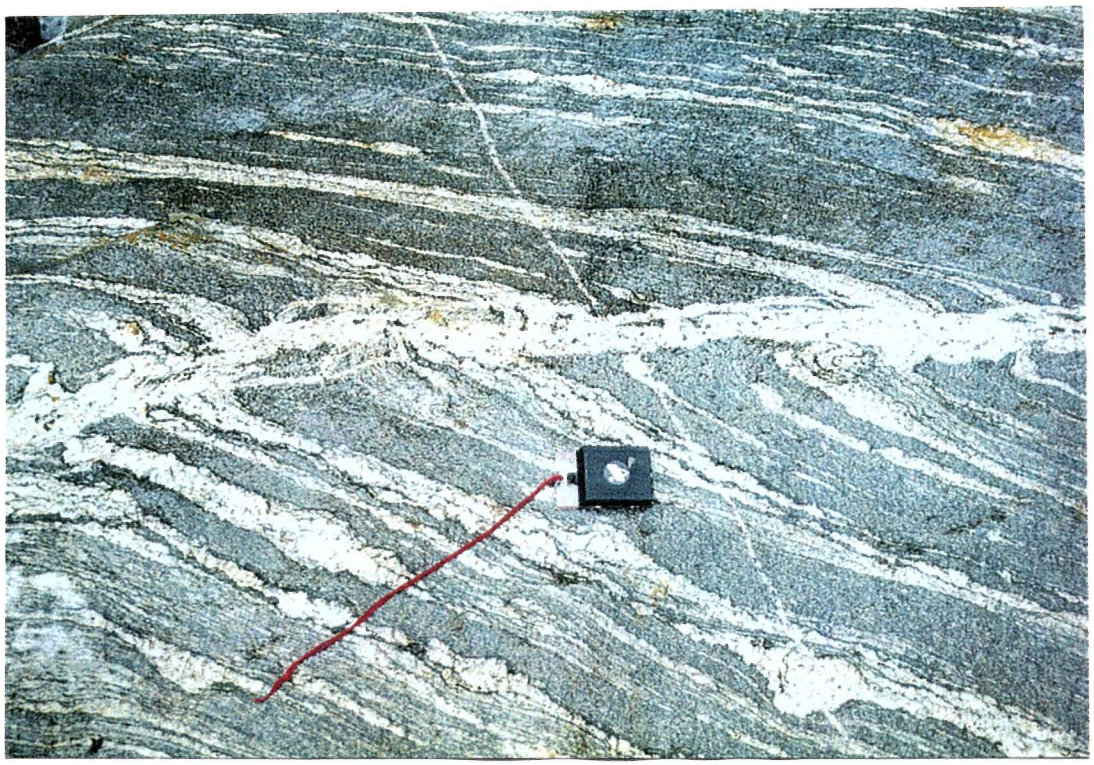


Plate 4. Dextral deformation of gneissic banding wich intrusion of leucogranite along the shear.

CONCLUSIONS

The main findings of the field study are:

1. The Jutial Pluton is a mineralogically diverse body within which three facies have been recognised on the basis of mineralogical, deformational, and emplacement characteristics, the "main Jutial facies" and two "marginal" facies.

2. The main part of the Jutial Pluton appears to have been constructed by a process of multiple sheeting into active low-angle reverse faults. This led to the development of a pervasive, contact parallel PFC fabric throughout the body.

3. Continued deformation during the later stages of intrusion resulted in the imposition of solid state strain within the northeast part of the complex, producing CPS fabrics.

4. Within the central parts of the body, it is envisaged that crustal shortening was accomodated by the development of a system of conjugate shears. The resultant PFC lock-up shears were exploited by leucogranite melt (marginal facies A).

5. After crystalisation and a significant amount of cooling of the Jutial complex, a later phase of regional tectonic deformation resulted in the emplacement of a suite of leucogranite dyke-like bodies (marginal facies B), which cross-cut the main plutonic fabric.

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EXPEDITION APPENDIX

EQUIPMENT

As none of the expedition team had had previous experience of the Himalayas, although most had trekked in the Alps, we sought advice from the members of the previous Durham expeditions before deciding what equipment we should take. In retrospect we took far too much cold weather gear, because we didn't appreciate how much difference a few hundred meters of altitude can make to Himalayan weather conditions. We were expecting warm days and cold nights, however, we found that at the altitude at which we were working (2500-3000m), the days were very hot and the nights warm. A list of the personal and group equipment that we took is given below, along with a few comments on which items we found to be essential, and which ones spent the entire trip at the bottom of a rucksack. After the expedition some of the team went trekking, and found that if we had been working any higher we would certainly have needed better sleeping bags and warmer clothes, as temperatures drop rapidly in the evenings at altitudes greater than 3500m.

We decided not to take a huge amount of climbing gear, for safety purposes, with us because none of us had all that much experience using ropes, harnesses, etc. Also we decided before the expedidition, not to take any risks by visiting any exposures that were even vaguely difficult to get to. However, we did take an ice axe each just in case there were any low lying snow patches, but we would have needed to be at least 4000m before we reached the lowest glaciers, and 5000m before we reached any snow, so they had little value other for decorating our rucksacks. Before the expedition we did not anticipate having to swing across wires to get across rivers, and when we were faced with having to do so on the way to the field, we certainly wished that we had taken a harness and karibiners. We would advise future expeditions to check out carefully whether they might be faced with similar obstacles (if you're planning on travelling along any unmade road that crosses a river its a fairly safe bet that the bridge might have been washed away) to take at least one harness, rope and karibiners, so that you don't have to trust your life completely to the locals wrought iron and plastic rope contraptions.

Everyone visiting the Pakistan Himalayas should make themselves aware of the local attitudes to clothing, as determined by the Islamic code. We expected that once out in the field it would be alright wearing shorts and T-shirts. However, we quickly discovered that in the area in which we worked the locals were Shia Muslims, who take a particularly strong view against 'immodest' dress. We were told in no uncertain

terms that shorts were not acceptable, although T-shirts were OK. Also, the locals strictly observed purdah and it was common for the women to hide behind trees or rocks, when our paths crossed in the field.

Personal Equipment

Waterproof Jacket[1]	3 pairs socks	2 x 1 litre water bottles[5]
Waterproof trousers*	1 pair boots[2]	Petzl head torch
Fleece Jacket*	1 pair trainers/sandals[3]	Towel
Jumper	Karrimat	Plate/mug/KFS
2 T-shirts	Sleeping Bag[4]	Sunglasses
2 pairs trousers	60/80 litre rucksac	First aid kit
2 pairs shorts*	Daysack	
Underwear (boxers are best!!)		

* Equipment which never made it out of the rucksacks.

[1] Although the weather was generally excellent we did have a few days of rain when we needed waterproofs, although the weather was never bad enough to warrant using waterproof trousers as well as jackets.

[2] We spent the entire expedition walking on scree which put a fair amount of strain on our boots. We found that 2/3 season boots were adequately stiff, and the expedition was divided equally between those that preferred fabric boots and those that took leather. We found that the fabric boots were beginning to show their mileage quite badly by the end of the trip, with seams coming apart, but the leather boots were still in on piece and going strong.

[3] We cannot recommend the new style of hi-tech sandals enough for wear around camp. After a hot days walking they we ideal and a great deal more pleasant to wear than a pair of trainers in the heat.

[4] The nights were far warmer than we expected and 2 season sleeping bags were adequate at the altitude we camped at. From our trekking experience we would recommend future expeditions to take at least 3 season bags for camping above 3500m and 4 season for use above 4000m.

[5] Taking an adequate amount of drinking water into the field during the day was essential. We found it very difficult to find good water supplies in the field (see the section on water) and until you get above 3000-3500m there are very few small streams suitable for drinking water. It is better to take two small water bottles rather than one large one, because one can be used for drinking from while water is being treated with iodine in the other.

Group Equipment

1 Wild Country Tristar Tent	Numerous large self seal bags[10]
1 Jack Wolfskin Bike'n'Hike Tent[6]	Tea towels
1 Katadyn water filter	2 Tilley lamps[11]
2 10L Ortlieb waterbags[7]	2 blue plastic barrels[12]
1 25l fuel container[8](bought in Pakistan)	2 Curver 'Action Packer' crates[13]
1 Expedition first aid kit	2 Plastic bowls[14]
2 cooking pots[9]	
2 x MSR Whisperlite International Stoves[15]	

[6] This tent has the useful feature of a huge bell-end, which meant that we could store all our equipment inside during the day and at night, which probably saved us a large amount of hassle from petty thieving (which we were warned about by several people in Gilgit).
[7] The water bags proved to be one of the more useful pieces of gear we took, as we had to carry our water supplies quite a distance to our camp in Jutail.
[8] We bought a large plastic jerry can in 'Pindi for our paraffin because every guide book comments on the difficulty of finding leak-proof containers in Gilgit. However, we saw plenty of containers just like ours in Gilgit, so presumably the situation has changed.
[9] We bought our cooking pots in Gilgit to save space on the flight out, there are numerous pots and pans shops in the bazaar. We also bought a pressure cooker in 'Pindi which turned out to be another superfluous piece of equipment, as we weren't at a high enough altitude to really need it. It did however, make a good present for our guide at the end of the trip! Again the guide books recommend you buy pressure cookers in 'Pindi, but we saw plenty for sale in Gilgit.
[10] These were without a doubt the most useful items we took, used for a million and one purposes.
[11] Tilley lamps are available in Gilgit and depite being a pain to transport without breaking, were really handy on the numerous occasions the food took longer to cook that we anticipated .
[12] From the evidence we saw you are clearly not a professional expedition in Pakistan unless you have numerous blue plastic barrels for your porters to carry! They are available from trekking companies in the UK, but we bought ours in Raja Bazaar, 'Pindi. To find the barrel shop take the road from the main roundabout towards the Old Fort. Turn left at the GPO and the shop is approx. 150m down the road on the left.
[13] We bought these plastic crates in the UK to transport our dehydrated food in. They were excellent in field as seats and to store our cooking equipment away from the flies.
[14] Available in Gilgit, handy for washing - especially yourself in a tent when there are too many locals around to strip off beside a stream.
[15] Everyone we spoke to before the expedition recommended the MSR stoves for use with paraffin in the field. We thought they were terrible! The jets clogged up almost daily, and stripping the stoves to clean them became a daily ritual. We also found that we had to be careful not to get dust in the pumping mechanism (yet another use for the self-seal bags). Having said that they were easy to repair, boiled water quickly and were economical on fuel (we used about 1L of paraffin every 3 days). We did find that when we went trekking we had far few problems with the stoves because carrying them around all day enabled the shaker jets to clear themselves automatically.

FOOD

We decided to take most of our food supplies with us from the UK., because we were not sure what would be available in Pakistan. McDougalls brand catering packs of dehydrated meals formed the mainstay of our diet. In retrospect, the only positive thing we can find to say about them is that they weighted very little. Unfortunately,

they taste pretty bad, and worryingly the beef curry stained our plates fluorescent green. Fortunately, we did road-test them before going to the field area and bought plenty of tinned goods (baked beans, peas, corned beef, tuna etc.) in Pakistan, to try and make them a little more palatable.

We also took out plenty of cup-a-soups, Smash (good for thickening up the dehydrated meals), boiled sweets, Tracker (museli) bars and dehydrated milk. We supplemented our supplies from the UK. with jam, biscuits, rice, lentils, flour, sugar, salt and cooking oil from shops in 'Pindi and Gilgit. We did most of this additional shopping in 'Pindi, because all the guidebooks give the impression that very little is available in Gilgit. However, we found the selection of tinned and dried goods available in Gilgit was just as good as that in 'Pindi, and buying the goods in Gilgit would of course save the hassle of transporting them up the Karakoram Highway. The best shop we found was the Marshal Bakary, 2 doors down from the Park Hotel. The shop wallah will send his son out to fetch anything you can't find in his shop. There is another good shop for canned goods on Airport Road near the Skyways Motel.

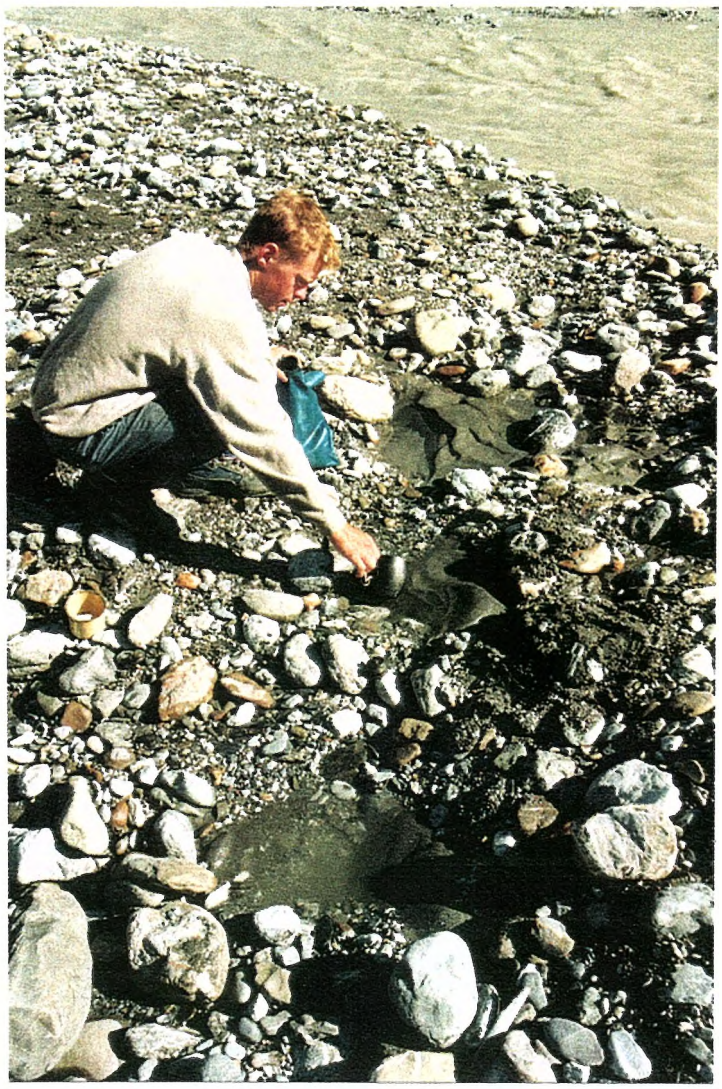
We found that we ate far less than we expected in the field because it was so hot, and even those members of the team who didn't catch any horrible stomach complaints, still lost a significant amount of weight because the dehydrated food had so little nutritional value.

WATER

Obtaining a decent supply of drinking water was our biggest logistical problem in the field. The field area was very arid and the only stream was the Purapash River in the centre of the valley, which was too heavily laden with sediment to be able to filter it. The locals extracted water from the river to irrigate their fields, but even in the comparatively slow flowing irrigation ditches the water was still too dirty to use for anything other than washing. We eventually found a marshy area about half an hours walk from the camp, where we managed to get a trickle of clear water going by making a small dam with a few stones. Again, altitude is a major factor in determining whether you can find a suitable water supply. At greater altitudes there are more streams because the drift is thinner so less of the glacier melt can soak away and the water is cleaner because there is less drift to erode.

We treated our drinking water in two stages. Firstly, by filtering through a Katadyn Pocket Filter followed by chemical treatment it with iodine. The filter removes

everything > 2um in diameter, that is all cysts and bacteria, but not viruses. The iodine then kills off the viruses, and also ensured our water bottles did not get contaminated. We used half the iodine dose recommended on the bottle, because we reckoned that the filtering would remove most of the nasty that the iodine could have killed off, and also iodine doesn't do your insides much good, so we were keen to ingest as little as possible. We could have used a chlorine based treatment (e.g. steritabs) instead of the iodine, but we found that made the water taste even worse than the iodine. Note that chlorine treatments do not kill cysts (i.e. Gardia), so they cannot be used safely without filtering the water first, but iodine kills everything so filtering is not strictly necessary.



Using the locals method of cleaning sediment laden water.

Our method of water treatment was quite a hassle but those that stuck rigidly to it suffered no stomach complaints at all, whereas those that were tempted for a quick drink straight from the stream suffered the consequences.

We discovered one handy solution to the suspended sediment problem while trekking, which would have solved our water problems in the field. We found that by digging holes in the point bars of even the most sediment choked river, you can obtain a supply of crystal clear water because the slow seepage of water into the holes through the bar filters out the sediment.

FUND RAISING

Before beginning fund-raising we looked through numerous old expedition reports to try identify the sorts of companies that usually sponsor expeditions. The answer was simple....not very many. So we decided to save ourselves a lot of unproductive letter writing, and concentrate on raising money from trust funds rather than industry. The only companies we did try were the oil majors (purely because we were a geological expedition), and we were lucky enough to obtain sponsorship from B.P. and Shell.

Our approach in applying to the trust funds was to try and appear as professional as possible. We spent a great deal of effort making the application forms presentable, and wrote a summary of our expedition objectives, which emphasised how important our findings would be that could be understood by a non-geologist. We also realised the prestige associated with being approved and supported by the Royal Geographical Society, and applied for their support 18 months before the expedition. We received confirmation of their approval and support November 1994, and we were able to quote this in our subsequent trust fund applications. We are sure that having the backing of the Society was a major factor in our fund-raising being so successful, and in the end only one trust fund failed to support the expedition.

VISAS / INSURANCE / MONEY

Due to an administrative blunder at the passport office in Liverpool, we had to obtain our visas at the last minute from the consulate in Bradford. This was no problem at all and provided visa applications are received before midday, you can get your visa the same day.

In addition to having your visa, you are supposed to register with the police if you are staying in the country for more than 30 days. The registration office in 'Pindi is at the police station near to the law courts. When we went to register we were told citizens of the UK., Australia and the U.A.E. were no longer required to register and we got no bother from customs when we left for not having registered. However, official policy seems to change fairly frequently in Pakistan so future visitors would be advised to check at the registration office again, just to make sure that the situation hasn't changed.

We obtained our insurance from Thomas Cook after looking at numerous policies from various companies. Our main concern was that we should be covered from repatriation in case of a medical emergency. We were also warned by previous expedition members, to check that the policy would cover us for loss of equipment, if the equipment was lost when being used for a purpose other than that for which it is intended. For example some 'expedition insurance' schemes will not payout for an ice axe which is lost during a stream crossing. The Thomas Cook policy seemed to have everything covered, but fortunately we didn't need to make any claims.

We took our money in American Express Dollar Travellers Cheques, because American Express has an office in 'Pindi, so if we had had any stolen it would have been reasonably easy to replace them. However, we heard from other travellers that the replacement service in 'Pindi isn't quite as efficient as the adverts make out - so don't lose your cheques. Changing money was easy, once we got used to taking part in the scrummage infront of the cashiers till. Exchange rates at the airport were the same as in town, so there's no real need to take any rupees out with you. We didn't find any significant change in the exchange rate northwards in Pakistan, (we got 1 rupee less per dollar in Gilgit compared to 'Pindi), which is reported in some guidebooks.

LOCAL HASSLES

We had a constant stream of locals asking us for medicines for everything from bellyaches to dwarfism. Because we had no medical training and didn't want to become the local mecca for every ill local, we refused medicines to everyone. The most common complaints were eye diseases, and future expeditions with any medical knowledge might want to take a supply of appropriate creams etc. to treat these afflictions.

RESEARCH PERMISSION

We spoke to numerous people who have worked in Pakistan before the expedition, to try and find out what the position is regarding permission to research in Pakistan. We wrote to the embassy in London, the British Consulate in Islamabad and several academics in Pakistan. We didn't get a straight answer out of any of them.

Apparently, there is an official form that you should have, but all the British academics who work in Pakistan that we spoke to said that whenever they have tried to get hold of one, they have usually been told that the forms haven't been printed. We didn't get replies from the embassy or the academics in Pakiistan that we wrote to, so we don't know what their recommendation would be. We found that there was no trouble with just getting out into the field and getting on with the work. We even had the local policeman as our guide for the first part of the tri, and he seemed to have no problems with us being there. However, we didn't have any large, obviously scientific pieces of equipment, so perhaps future expeditions that need to use such gear might want to get hold of some sort of official looking document to wave at people if need be.

INTERNATIONAL TRAVEL

Several airlines fly from the U.K. to Pakistan. We decided to take the quickest route of flying straight to Islamabad rather than connecting through from Karachi, which limited the number of airlines we had to choose from. We also had to consider how we were going to freight out our gear, and when we found out that PIA offer 20kg excess baggage on outward flights the decision was simple, despite the flights being relatively expensive.

We reconfirmed our return flights as soon as we arrived in Pakistan, just in case we had any hassle getting back down from Gilgit. You require photocopies of your passport when reconfirming your flight.

INTERNAL TRAVEL

The tourist infrastructure in Pakistan is developing rapidly and getting up into the hills is relatively straight forward. The choice of transport is between; (i) buses - by far the cheapest but a hassle if you have loads of expedition gear, (ii) flying - the quickest,

most expensive and most spectacular, but again lots of hassle if you have loads of gear or (iii) private minibus.

We went for the private minibus option because of the amount of gear we had, and because we thought it would be relatively safe. As you can read in the Expedition Report it didn't turn out to be very safe at all. If you are hiring a minibus we would recommend that you ask to meet the driver beforehand, to make sure that you don't get some young nutter. We looked at three companies before hiring the minibus. Pakistan Tours at Flashmans Hotel who were by far the most expensive. Saeed Wagon in Raja Bazaar, who were the cheapest and also the dodgyist and Hameed Coaches next to the Pir Wadhai Bus Station, who seemed to be a half-way house between the first two. We realised later in the trip that the last two operators hire their staff from a pool of drivers who hang around 'Pindi until a fare turns up, so the chances of getting a reasonable driver are slim.

Returning to 'Pindi from the field Jon and Dante caught one of the half-bus sized coaches operated by Masherbrum Tours. The journey was excellent compared to our trip up the highway, despite being crammed in like sardines. At least there were two drivers and they didn't drive like maniacs.

Simon and Jipper caught the PIA plane down from Gilgit to Islamabad. Two seats are reserved on each flight for tourists, and to get them you need a letter from the tourist office at the PDTC Hotel. Usually these seats are booked weeks in advance, but if you preserve you can get a letter even when the two tourist seat have supposedly been sold. Also, we heard that you can often get on the flight if you just turn up at the airport and wait, as there are often spare places on flights because PIA hands out so much misinformation about the service.

PORTERS

Negotiating with the porters was definitely one of the most frustrating and entertaining aspects of the expedition. Unfortunately, we didn't mange to get hold of a copy of the official regulations for hiring porters, which would probably have saved us a fortune as we clearly overpaid or porters by quite a margin. An essential piece of kit for anyone hiring porters is a spring balance weighing up to 50kg (available in the bazaar in Gilgit), so you can weigh your porter loads in front of them, and convince them you haven't made the loads greater than 25kg.

We gave them a couple of cigarettes a day in addition to their wages and also took out a supply of ball-point pens as gifts. When we arrived in the field area we felt somehow mean and colonial just handing out pens, so we kept hold of them and didn't give out any gifts until the end of the expedition, when we gave away our excess food and gear (the tilley lamps, plastic bowls etc.). One thing that would have gone down very well as gifts are English primers, as nearly everyone in the valley we worked in seemed to be learning English by correspondence courses. They are available in the Friday bazaars in 'Pindi for a few rupees each, and would be far more valuable to the local than a few ball-point pens.

MEDICAL REPORT

As a condition of receiving financial support from the University, half the expedition had to attend a first-aid course run by the St. Johns Ambulance.. Several expedition members had also had first-aid training as part of Duke of Edinburgh and other courses, so we felt reasonably confident of being able to cope with most injuries. We considered the option of paying the helicopter bond so that we could be rescued in the event of a serious injury, but decided against it for several reasons. Firstly, because it would have been very difficult to get intouch with the military had we needed a helicopter, and apparently they are unlikely to come and pick you up if you are away from their main area of activity in the Baltoro Glacier area. Also, we reckoned that we would probably be able to get back to Gilgit within 24 hours by road in an emergency, which would probably be quicker than waiting for a helicopter. Before the expedition we were vaccinated against Polio, Tetanus, Cholera, Typhoid, Hepatitis A and Rabies, and during the expedition we all took a course of malaria tablets. Although we weren't working at particularly great altitudes we all made ourselves aware of the symptoms of Pulmonary and Cerebral Oedema.

We took an extensive medical kit with us, kindly supplied at a bargain price by the University Medical Service, which was kept in our base camp. We also carried personal first-aid kits to deal with the day to day cuts and blisters.

At camp we paid particular attention to hygiene in order to reduce the risk of contracting stomach complaints. On the whole we successfully avoided too many upset stomachs. Minor cases were treated with oral dehydration salts and Immodium, and one more serious case of Gardia was treated with the antibiotic Flagyll which was purchased in Gilgit.

SUGGESTIONS FOR FURTHER WORK

Our original field project was hampered by a lack of accessible exposure. While trekking after the expedition we visited two area which had much better, and more accessible exposure, although we haven't checked whether much work has been done in the areas before.

Firstly, the Ultar Gorge which leads up from Karimabad to the Ultar Glacier exposes a beautiful section through a contact aureole into a deformed granite. There are at least 4 intrusive phases in the pluton and some show good deformation fabrics. Secondly, the Baltoro Glacier has lots of reasonably good exposure along its length but water supplies are scarce until you get two days walk up the glacier. Again the exposure is of deformed granites (? mostly sheet-like bodies) and metamorphics.

EXPEDITION ACCOUNTS

INCOME	£	EXPENDITURE	£
Albert Rickett Charitable Trust	500	Pre-expedition stationary	68.50
British Petroleum	200	Travel to interviews	108.80
Foreign School Society Fund	500	Food	492.20
Gilchrist Educational Trust	500	Medical	129.97
Mount Everest Foundation	700	Insurance	555.50
Royal Geographical Society*1	800	Visas	96
Shell International Petroleum Ltd	1000	Equipment	587.57
St. Johns College	700	International travel	2116
University of Durham	500	Accommodation	188.60
Personal Contributions	56.89	Internal travel	222
		Porters	216
		Report production	75.50
Totals	4856.89		4856.89

*1 This grant includes a contribution form the Rolex Watch Company.