IMPERIAL COLLEGE

OF SCIENCE & TECHNOLOGY

# MINAS DE LIPEZ EXPEDITION

# BOLIVIA, 1966

THE EXPLORATION BOARD.

GDAE 12/34

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Imperial College Exploration Board
March, 1968.

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# INTRODUCTION

by

Alan Cope

The expedition was born one evening in 1965, when Tony Morrison was invited by the College Exploration Board to give a talk on his experiences in the Sud Lipez province of Bolivia.

Two hundred years ago, Sud Lipez had been one of the richest silver mining areas in the fabulously wealthy New World, but now, as Morrison's film showed, the once booming mining towns lie empty and abandoned, the mines desolate, decaying, unworked for generations.

One of the biggest of these mining towns, San Antonio de Lipez, has remained almost exactly as it was when the Spanish left; the cathedral is still unbelievably intact, and the profusion of elaborate carving, gilding, and silver work around the altar-screen testify to the former wealth of the area.

Morrison's film of this unique ghost town high up in one of the remotest parts of the Bolivian Andes fired our imaginations, and Tony Read and I decided to follow up his suggestion that an investigation into the collapse of the mining industry in the area would make a suitable project for a student expedition. From that date until we finally sailed on 12 July 1966, we were involved in usual interminable mass of preparations.

First, there was research on the area to be done, by us in the libraries of London, and by Jeffrey Powell, a Cardiff University

Spanish student, in the Archives de Los Indes in Seville, Spain.

Then, during the summer of 1965, we recruited Jeffrey O'Leary and Peter Francis to complete the party, and in addition arranged for a couple of reserves, who were fortunately not called upon.

In October, the party gained Exploration Board approval for the proposed expedition, and for the next year we received full support from this authority. We are extremely grateful for the unselfish assistance given to us by the members of the Board, and in particular we would like to record our appreciation to the contribution of Mr. A Stephenson, Chairman of the Board, for his interest in the expedition and for the benefit of his experience gained through many years of involvement with expeditions.

We next prepared a brochure explaining the plans of the expedition, and this proved to be of considerable value in our fund-raising activities. The details of donations are included in the financial report, but the most important contributions came from the Board and from various mining companies, particularly Capper Pass & Son Ltd., for which we are very grateful.

We were not so successful in our applications for grants and approval from the Mount Everest Foundation and the Royal Geographical Society. Our grounds for support from the M.E.F. were obviously very thin, but it was a great disappointment that the R.G.S. considered our expedition unworthy of approval. Their reason apparently was because we were concerned with economic geology, and not with the production of geological maps.

Generous help also came from Lobitos Oilfields Ltd., who offered us free transport on one of their oil-tankers to and from South America. These free passages, which were instrumental in the Expedition's becoming a going concern, was obtained through the efforts of Professor W.D. Gill, of the Oil Technology Department.

In our attempts to obtain co-operation from various Bolivian authorities, we were much hindered by the slow and unreliable postal service, and the traditional "manana" philosophy of our correspondents. However we were grateful for encouragement from the Minister for Mines and Petroleum, and for offers of assistance from the Bolivian Geological Survey (Geobol). We are particularly grateful for the help and hospitality of one of Geobol's senior geologists, Senor Ismael Montes d'oca.

The months of correspondence and anticipation suddenly came to life in the Spring Term of 1966, when tangible results of our efforts appeared; first in the form of cheques, then, gradually a mountain of equipment and food began to accumulate in a basement room in the Chemistry Department of Imperial College.

The Land-Rover was bought and checked over, and all our plans seemed to be going smoothly, exactly according to the schedule we had worked out months before. This was perhaps too good to be true, and when the setback finally came, it turned out to be nearly the end of the expedition. It was the seaman's strike of May and June 1966. All our plans rested on the free passages to and from South America; as the strike dragged on, it became clear that we would never be able

to go ahead with our original programme; indeed at one stage it looked as though the expedition would collapse before it set foot on foreign soil.

However, the Exploration Board splendidly stepped in to save us from complete disaster with a generous contribution towards air fares, so that we would be able to fly back to England, returning only a few weeks after the beginning of term. The strike still cost us dear, however, in the form of weeks of uncertain waiting and frustration, and in a rather curtailed period in the field.

Anticipation and planning are reputed to be some of the most enjoyable aspects of an expedition; these weeks of worry and uncertainty were completely the reverse, being utterly depressing and corrosive, and it was with considerable relief that we finally embarked at Liverpool on 12 July, on the first step of our long and complicated journey.

What follows in this report is an account of the following three months, of what we saw and what we did, of the miles we drove and the money we spent, and, most important of all, of the silver mines in Sud Lipez.

# DAY BY DAY ACCOUNT OF THE EXPEDITION

by

Peter Francis

Tuesday, 12 July - 04.30 hrs: The party sailed from Cammell Laird's yard at Birkenhead, on board the M.V. "El Lobo". An undramatic, unspectacular departure from Britain. The ship lay hove-to for several hours off the Welsh coast while engines were repaired.

Wednesday, 13 July - Thursday, 21 July - Ploughing steadily across the Atlantic. The tanker rolling a lot initially, with some sea-sickness amongst the party. Later, the sea much calmer and very pleasant cruising weather.

Friday, 22 July - First sight of land - Sombrero Island in the Virgin Islands - marking our entry into the Carribean. Passed close by the Island of St. Croix in the early evening - a fascinating scatter of twinkling lights against the gathering gloom of a tropical evening.

Saturday, 23 July - Steaming steadily across the Carribean in splendid tropical weather, ideal for sun-bathing.

Sunday, 24 July - First sight of South American mainland - the rather dismal coast of Venezuela at the tip of the Gulf of Maracaibo. Anchored off Punta Cordon at about 08.00, docked later the same day. Went ashore later on, to find the town itself to be a featureless refinery sprawl, with a depressing shanty town outside the refinery gates. Most of the population seemed to live off the immoral earnings of the numerous prostitutes.

Monday, 25 July - Sailed from Cordon at noon. No one particularly sorry to leave. Weather extremely hot and humid with following winds, both this day, and Tuesday. Captain celebrated his Twenty-Fifth Wedding Anniversary on Tuesday night, and the gathering in the ship's lounge bar was soon soaked in sweat.

Wednesday, 27 July - Passing along the jungle-covered coastline of Panama, anchoring off Cristobal in Panama Canal Zone at about 10.00. At anchor all day long in the still, listless, harbour. Started moving through Canal at 21.00 - a splendid warm tropical night, with intriguing jungle noises coming clearly from the land on both sides of the ship.

Thursday, 28 July - Left Canal in early hours of the morning. The Pacific is not terrific! Weather heavily overcast with occasional showers. Steaming steadily south all day, and on Friday, the 29th, the party began to make final preparations for disembarkation at Talara in a few days' time.

Saturday, 30 July - Anchored off La Libertad in Ecuador in early hours. Ship tied up to buoys 2½ miles off from shore and began pumping oil along a single, narrow, leaking pipe-line. Party ashore by lighter in afternoon, for sight-seeing in La Libertad and the nearby resort of La Salinas.

Sunday, 31 July - Pumping of oil continued all day along the rickety old pipe. Party ashore again in the morning and afternoon for sight-seeing and swimming at La Salinas.

Monday, 1 August - Ashore very early to catch a bus from La Libertad to Guayquil, the commercial capital of Ecuador. An extremely interesting 90-mile ride; the town itself turned out to be very crowded and colourful, but was chiefly memorable for its appalling waterfront smell.

Tuesday, 2 August - Pumping stopped for long period, while more space was found at the other end for the oil. Finally sailed at 18.00. Party completes preparations for going ashore at Talara.

Wednesday, 3 August - We dock at our destination, Talara, in the early hours of the morning. All the crates of gear and our baggage are lowered into lighters and taken ashore. The party takes final leave of the "El Lobo", and is welcomed ashore by Senor Careras of the International Petroleum Company who books the party in at the Royal Hotel.

Thursday, 4 August - Off at 09.00 with Senor Careras to Immigration, where clearance is soon obtained. Alan and Jeff then catch the Expreso Sudamericano bus to Lima, travelling independently to La Paz, in order to arrive ahead of the Land Rover party and clear the way. Tony and Peter spend an uneventful but pleasant day in Talara.

Friday, 5 August - Senor Careras tackles the Customs for us again in the early morning, but with no result. To Customs again at 15.00, where after a one hour wait, action suddenly takes place. Clearance rapidly obtained for all our gear and the Land Rover, which had arrived at Talara on board the S.S. Kenuta. The evening was spent in preparing, loading and packing the Land Rover for the journey south. Tony and Peter were entertained by Senor Careras, both in his house where the packing was done, and at the Talara Club, where they enjoyed a splendid meal with him.

Saturday, 6 August - A hard morning's packing, and a great deal of time and effort by Senor Careras in trying to locate suitable nuts for the Land Rover spare wheel. Finally hit the road at 14.00, driving steadily south through Piura and Sullana, where became rapidly lost in a maze of one-way streets with, of course, not a single sign post to show the way. This was absolutely typical of towns everywhere in Peru and Bolivia. Stopped just short of Chiclayo at about 22.30, sleeping out in the open desert.

Sunday, 7 August - Driving steadily all day from 06.30 to 20.30. Magnificent desert scenery up and around Trujillo, where became hopelessly lost in maze of streets once more.

Monday, 8 August - Off at 06.30 again, and driving south along Pan. Am. Highway, again through splendid desert scenery. Arrived in Lima just before lunch, where by great good luck met a young chap who was going to I.C. in October. He found us a very reasonable hotel in the centre of the city where we put up for the night. Spent most of our time in Lima in seeing various people, and in wandering up and down the Avenida Iquitos looking for car jacks. With all systems go, left Lima at 14.00 and spent nearly two hours trying to find the right road out of town. Slept out overnight just north of the Plain of Nazca.

Wednesday, 10 August - Off at about 06.15. Spent some time on the Plain looking at the famous Lines of Nazca. Then pressed on steadily south, following the coast as far as Camana, where the road turns inland and climbs up to Arequipa at about 8,000 ft. Here we arrived at about 21.00 and put up in a cheap hotel.

Thursday, 11 August - Slept in for the first time for several days. Spent the day servicing the Land Rover and ironing-out minor faults, and in looking briefly round the town. Much impressed by splendid views of the volcanoes dominating the town, which is reputed to have clear blue skies on 360 days of the year.

Friday, 12 August - Left Arequipa at about 08.00. Left the asphalt Pan-American highway, and turned off on to the dirt track that was to take us over the backbone of the Andes and down to Puno on the other side. This involved a long slog up an incredibly tortuous road to about 15,000 ft., when the road flattened off by the side of a dazzling pure white salt lake. Then the road led for miles through undulating Alturas, before winding down gradually to Puno, on the shores of Lake Titicaca, 12,250 ft. where we arrived at 17.00, sharing the Hotel Turistas with a prominent member of the B.B.C. "Panorama" team.

Saturday, 13 August - Off at 09.00, driving along the shores of Lake Titicaca, with splendid scenery of the deep blue lake with snowy mountains in the background, and balsas (reed boats) in the foreground. Arrived at the Peru-Bolivia border at Desguadero in the afternoon, and completed the necessary formalities without trouble. A set-back at Guaqui, twenty miles from the border, where the police control post declared we had entered the country illegally. Back to the Bolivian authorities' office at the frontier to get the appropriate rubber stamps, and then back to Guaqui. This time the police were satisfied, and we pushed on for La Paz in the gathering dusk, passing the ruins of Tihuanaco just as it was dark. Arrived in La Paz, and put up in a rather scruffy hotel, the Hotel Italia.

Sunday, 14 August - Spent the morning making fruitless telephone calls trying to contact the other half of the party, Alan and Jeff.

Finally established contact outside the Protestant Church, and then exchanged experiences of the last ten days or so. Moved belongings into the Grand Hotel Neumann and then all four members of the party spent the afternoon sight-seeing around La Paz.

Monday, 15 August - A busy day for all, mainly spent going round the offices of various organisations, getting affairs straightened out for the departure for the field next day. Alan and Jeff had used their time in La Paz profitably, and everything was under control. Geobol (Servicio Geologico de Bolivia) undertook to attach another vehicle to the party, a Chevrolet, plus a driver and one of their senior geologists, Senor Ismael Montes de Oca.

Tuesday, 16 August - The morning was spent in final preparations and arrangements. Alan was to travel in the Chevrolet, which was delayed by mechanical trouble. Tony, Jeff and Peter set off in the crammed Land Rover, and after spending 90 minutes looking for the right road out of town, finally get started on the road south to Oruco and Challapata, where they arrived at 20.45 in time for a scratch meal at a small but friendly hotel. The Chevrolet party arrived some hours later in good shape.

Wednesday, 17 August - Departed from Challapata at about 09.30 Drove south all day along appallingly bad roads with enormous corregations, but compensated by marvellous altiplano scenery. Reached the town of Uyuni, on the vital rail junction

where the railway forks, one branch leading to the Pacific at Antofagasta, and the other to the Atlantic at Buenos Aires. Took on petrol in 44-gallon drums, and stocked up with fresh fruit, vegetables and bread ready for the journey into the wilds next day.

Thursday, 18 August - A hard day's driving, at times along almost non-existent roads, heading steadily south for our destination, San Antonio de Lipez. Notes on the route provided by Tony Morrison proved invaluable here, as they had done all along, and with their help we found our way across the 120-odd miles of desolate altiplano without a slip. At about 16.30, 39 days after leaving London, we arrived at our destination, San Antonio de Lipez, an abandoned town, straggling down a desolate valley, 15,200 ft. up in the Andes. The town was entirely deserted when we entered although there were clear signs that it was, at least occasionally, inhabited. We found one of the crude rock-built huts which still retained its thatched roof and set up camp in it. The Chevrolet party arrived in due course, having come via San Cristobal, and in no time at all the party was settling into its new quarters.

Friday, 19 August - The morning was spent in setting the camp in order, then while Tony and Alan continued this task, Jeff, Peter and Ismael Montes de Oca set off on a preliminary reconnaissance, which revealed only some comparatively new adits, dug in the 1870s. The afternoon was spent in a brief preliminary exploration of Mesa de Plata, which turned out to be extremely impressive.

Saturday, 20 August - The party woke up feeling generally unwell, due to the effects of altitude, and consequently only light work was done. Ismael set off to reconnoitre some mines to the east of Mesa de Plata, but unfortunately the side of the road gave way beneath the Chevrolet, which became stuck. Ismael and his driver, Hosea, had to walk the 10 kms. home.

Sunday, 21 August - After spending some time digging the Chevrolet out, the rest of the day was spent on the mines above San Antonio, which proved to be quite promising.

Monday, 22 August - Attempted to find Escala mine unsuccessfully in the morning, and in the afternoon drove to San Pablo, looking briefly at a co-operative copper mine on the way.

Tuesday, 23 August - The morning was spent in a preliminary examination of the mines south west of San Pablo - Buena Vista and San Juan mines. These proved most interesting, and promised to provide us with plenty of material. In the afternoon, an attempt was made to find Mestizo mine west of San Antonio, but this was abandoned when the road petered out to nothing on the steep hillside, and required a brilliant piece of reversing by Hosea to get the vehicle facing in the right direction once more.

Wednesday, 24 August - The whole day was taken up on a long drive to San Salvador and Bolivor mines some 25 miles south west of San Pablo. The road was extremely tortuous, winding its way through very rugged

country, but provided some spectacular scenery. The object of the trip was to obtain permission from the mine manager at San Salvador to work on the mines near San Pablo, and having done this, we were shown around Bolivar mine, which is still being worked for bismuth.

Thursday, 25 August - A day partly spent in general duties, taking up most of the morning. Tony, Jeff and Ismael set off in the afternoon to try and locate an antimonite mine west of San Antonio, while Alan and Peter spent the afternoon on the slopes of the Cerro de Lipez, looking for a silver mine, Neuvo Mundo mine, that was shown on our maps but which we never in fact found.

Friday, 26 August - Ismael and Hosea left in the Chevrolet in the morning, carrying with them our mail, to be posted in La Paz. The day was spent plane-tabling around Mesa de Plata, and excellent progress was made.

Saturday, 27 August - Tony, Peter and Jeff spent most of the working day underground in Mesa de Plata, while Alan remained at camp conducting a meteorological experiment.

Sunday, 28 August - Alan and Rony set out for Uyuni, to stock up with petrol and fresh food. Jeff and Peter remained behind to study some of the buildings in San Antonio. Excavation around the ruined smelter reveals some interesting features, such as the sand pit in which the silver was presumably cast into ingots. The bitterly cold, strong winds prevent work on the hills.

Monday, 29 August - Another day of biting winds. Jeff and Peter spend the day examining and sampling spoil-heaps around the mines near San Antonio. Many interesting specimens collected, but little of economic value. During the day, they also stumbled across another deserted town, believed to be called Machacabouy. This town is as big as, or bigger than, San Antonio, but is completely ruined and contains numerous artifacts, many of them probably of comparatively recent age. Alan and Tony return in the Land Rover in the evening, extremely dusty and travel weary, but with all their shopping done.

Tuesday, 30 August - Tony and Jeff spend the day in detailed sampling of the spoil tips at Mesa de Plata, employing a local Indian to do some strenuous hole-digging. Alan and Peter make a reconnaissance of the west ridge of Cerro de Lipez, reaching 18,000 ft. fairly comfortably. A minor fire caused by a leaking petrol lamp created some diversion during the evening, at the cost of one member's hair.

Wednesday, 31 August - Alan, Peter and Jeff spend a day in bitterly cold winds, surveying the mines between San Antonio and Mesa de Plata. Tony and an Indian continue sampling at Mesa de Plata, digging a particularly deep pit. Senor Rivas, another Geobol geologist arrives in the evening with Macedonia, his driver, and brings in large quantities of fresh vegetables.

Thursday, 1 September - Jeff and Peter spend the day underground in some of the adits between San Antonio and Mesa de Plata, while Alan botanises on the surface. Some really huge stopes are found during the course of a very successful day's work, but many adits are also found to be highly unsafe, with rotten wood props supporting very dangerous roofs. Some hazards obviously had to be expected if we were to accomplish anything, but these were kept to a minimum.

Friday, 2 September - A morning drive followed by a long, long walk in bitter winds finally took us to Mestizo antimining mine, which was rather a disappointment. Our Indian guide also intimated that Neuvo Mundo mine lay further along the path, but we decided not to continue, and returned to San Antonio to show Senor Rivas around Mesa de Plata mine.

Saturday, 3 September - Senor Rivas set off in the morning to go to San Cristobal. Peter and Jeff spent the day in making a photographic survey of the village of San Antonio, while Alan botanised. A splendid calm evening provided a good opportunity to photograph some of the plants growing in the area.

Sunday, 4 September - Most of the day was spent in surveying around Machacabouy, and then in examining some of the buildings in the town. Particularly interesting were the numerous pieces of broken pottery and a splendid example of an ore-crusher still perfectly intact.

Monday, 5 September - Tony and Jeff set off in the Land Rover to locate and study the mines at Escala - a lead/zinc mine and a malachite mine, both still being worked, were discovered and inspected. Alan and Peter left San Antonio on foot at 07.05 to climb the Cerro de Lipez, and were on the summit, 19,750 ft. by 12.15, returning to San Antonio by 16.00.

Tuesday, 6 September - Started surveying around San Antonio, but were forced to give up at about mid-day by the very strong, desperately cold wind which made manipulation of the instruments extremely painful.

Wednesday, 7 September - Wind still bitter, but not so strong, so surveying could continue. Photographs also taken of various features of interest for reference. Packing was started in the evening, ready for next day's removal to San Pablo.

Thursday, 8 September - Land Rover packed and ready to leave for San Pablo. Tony and Peter had got about one mile along the road when unpleasant noises began coming from the engine. This required a return to San Antonio, and the rest of the day was spent in stripping down the motor. The fault lay in the starter motor, various pieces of which had come adrift and were fouling the fly-wheel. These pieces were removed, and the rest reassembled, leaving us with a perfectly sound engine, but no starter motor.

Friday, 9 September - Alan, Tony and Jeff set off in the loaded Land Rover for San Pablo, while Peter remained behind to finish taking photographs of the cathedral and the village. The village which had been deserted when we arrived now appeared to be filling with people. Some twenty or so had arrived overnight, and many of these spent most of the day sorting through our rubbish sack to salvage what they could. We left them such food as we could, and then, when the Land Rover had returned from San Pablo, the party quit the village finally, setting up its new base camp in a derelict school-room in San Pablo.

Saturday, 10 September - The entire day was spent surveying around Buena Vista and San Juan mines, a good deal of ground being covered.

Sunday, 11 September - Petrol now being very low, a trip into Uyuni became essential. Tony and Peter made the run, which was rather alarming, in that the petrol gauge read 'empty' while the vehicle was still very far short of the town, right out in the desert. To our relief, the guage must have had a considerable zero error, for we made Uyuni with a little to spare, though it was obvious that we had been cutting things a little too fine!

Monday, 12 September - It had been intended to return to San Pablo, but the necessity of keeping a 16.00 radio schedule with La Paz meant that we had to spend the day in Uyuni. Over the radio, we tried to order the spare parts for the starter motor, but were

frustrated by not knowing the telephone number of the Land Rover agents in La Paz. The day was, however, usefully spent in having the broken back seats of the vehicle re-welded, and in re-stocking with fresh food, and, of course, petrol.

Tuesday, 13 September - After rising early, we made rapid strides; the telephone number of Martin and Company was located in some dusty old files in the offices of the railway workshop, and a brief radio conversation with the Company followed; the appropriate spare parts to be despatched as soon as possible. At 09.45 we quit Uyuni and were in San Pablo by 15.00 averaging some 20 miles an hour for the journey. What was left of the afternoon was spent in an inspection of Leoplan mine by Jeff and Peter. A very prolonged altercation in Spanish preceded this visit, the mine foreman being very conscious of his rights and privileges, but the visit proved to be well worth while.

Wednesday, 14 September - Surveying around San Juan and Buena Vists mines was completed, and then Jeff and Peter had a very strenuous time underground, getting a good look at most of the accessible workings and sampling where possible.

Thursday, 15 September - Three local Indian men were hired for the day to start on intensive sampling scheme of the spoil-heaps around Buena Vista and San Juan mines, and work was well on the way when our irascible mine foreman of previous acquaintance ordered

us to stop working, since we were impinging upon his rights. This was unfortunate, and meant we had to curtail our programme in these mines. The afternoon we spent on a visit to Santa Isabel mine, some 20 miles north east of San Pablo. There we found an originally extensive mine, now being worked on a pathetic scale for tin. The tip-heaps contained large amounts of pyrite which provided some interesting specimens, though there was nothing of economic interest. The drive back to San Pablo took 1½ hours, and was rendered unpleasant by the necessity of driving directly into a very low, bright sun along a track which left a lot to be desired.

Friday, 16 September - The morning was devoted to doing what we could underground in San Juan mine, principally in collecting specimens of some most interesting efflorescent products and in taking photographs of some of the mine installations. In the afternoon, preparations were made to leave, since there was now little else we could do. As much surplus food as we could spare was given to the local school teacher, to divide amongst the people of his village. This was received with considerable gratitude.

Saturday, 17 September - Final packing was done, and after taking our farewell of the village and its people, we left in the very heavily laden Land Rover for Uyuni, arriving at about 15.00. We were entertained that evening by Senor Armanza, a railway

engineer of previous acquaintance who spoke very good English and was keen to practise it. He provided us with afternoon tea, dinner and a most interesting evening.

Sunday, 18 September - Senor Huanca, the local Evangelist minister and railway foreman, very kindly agreed to guide us across the Salar de Uyuni, to Colchaka, 40 miles away. The drive across the Salar proved extraordinarily interesting, and had the extra fascination of providing one of the fastest tracks in Bolivia - we averaged 50 mph for considerable periods across the dead flat salt, heading directly for distant hills, sticking above the salt horizon. A spectacular grove of cacti, many of them 10 ft. or so high, provided further interest on the far side of the Salar.

Monday, 19 September - A day's work by the railway workshop fitters, under the guidance of Senor Armanza, was spent in designing and manufacturing a new castellated nut to fit the Bendix gear on the starter motor of the Land Rover. The other spare parts had arrived safely by rail from Martin and Cia, and, with the nut to fit, the starter motor could now be reassembled, and for the first time for 10 days we had the pleasure of starting the Land Rover without cranking it.

Tuesday, 20 September - Everything was now in order for the long trek home, and we set off on the first leg to Potosi. This involved a very, very long, hard day's driving along the worst road we were to encounter in Bolivia, but it did provide some unique scenery

and was a memorable experience. Arriving in Potosi, we booked in at the comparatively sumptuous Hotel IV Cent nario, where we had our first sight of hot, tapped water since leaving Lima. The first person we met turned out to be an English girl from New Milton, working at Potosi University. Small world!

Wednesday, 21 September - Sight-seeing around Potosi took up most of the morning, particularly interesting being the Casa de la Moneta, or Mint, where the silver from the mines in Lipez was made into coins for use all over the Spanish empire. In the afternoon, we went part of the way up the Cerro Rico, and then descended to the bowels of the earth in one of the very extensive tin mines in this mountain, which is practically hollow after 500 years continuous mining.

Thursday, 22 September - A very pleasant 5 hour drive took us to Sucre, the Colonial capital of Bolivia, and the most refined town in the country. We stayed at the curiously-named Hotel Londres, a pleasant little hotel built around a bottling works, and had a pleasant afternoon looking around the Cathedral, Museum of Colonial Art and the Museum at the University of Sucre. An ex-Bolivian diplomat who had lived in London provided some interesting conversation, particularly since his English, though perfect, was that of pre-War England, when he had lived in Kensington. His speech was thus spattered with idioms and expressions now long out of favour, but nevertheless an interesting reflection of England as it once had been.

Friday, 23 September - An early start, for some further sight-seeing in Sucre, and then off on a 9½ hour drive to Cochabamba, passing through some splendid scenery. The last part of this journey was on asphalt roads, the first we had seen since leaving Arequipa.

Saturday, 24 September - Arose to find that an enormous market had grown overnight, completely blocking the street in front of the hotel, and spreading over a large part of the town. This provided a fascinating day's sight-seeing with plenty of opportunity for buying souvenirs.

Sunday, 25 September - A long, hard drive down to Santa Cruz in the tropical lowlands of Bolivia; driving on asphalt nearly all the way. Alan and Peter rather sick, perhaps due to the effects of increase in atmospheric pressure, or food poisoning. Scenery again fascinating, in complete contrast to the arid, barren altiplano.

Monday, 26 September - A dusty morning spent looking around the new, booming wild-west town of Santa Cruz was followed by a drive to Portachaelo and beyond, as far as the Yapacani river, one of the tributaries of the Amazon. On the return, we encountered two members of the British Tropical Agriculture Mission, and spent a pleasant hour at the home of one of them.

Tuesday, 27 September - After a delightful breakfast eaten outdoors, the remainder of the day was spent on the long drive back to Cochabamba.

Wednesday, 28 September - Another long day's driving, taking us back to La Paz by 18.15, where we had our first baths since Potosi, putting up at the rather pretentious Hotel La Paz.

Thursday, 29 September - A busy day, spent in negotiations with Geobol and other groups, principally about the sale of the Land Rover. Established a sort of headquarters camp at Ismael Montes d'Oca's house, where we were to spend the next week or so.

Friday, 30 September - More intensive running about, dealing with various would-be purchasers of the vehicle. The first complication of the tax-set up on the vehicle begin to make themselves felt.

Saturday, 1 October - Thursday, 6 October - The attempt to sell the vehicle brings an avalanche of bureaucracy down on our heads, and by Wednesday it is apparent that complications and paper work are propagating themselves. Time is also running out rather fast, and it appears that at least another fortnight of endless negotiations and document-signing would be needed before we could sell the vehicle; even then the value of various taxes would be quite absurdly high. We therefore decide to cut our losses, and ship the vehicle back to England in desperation.

Friday, 7 October - Leave La Paz with a slightly sour taste in our mouths; heartily glad to have got away from the interminable hanging around various offices, but rather sad to leave such a fascinating and colourful city. Reach Puno in the evening.

Saturday, 8 October - It appears that having wasted so much time in La Paz, we will now have to return direct to Lima from Puno, instead of coming back along a much more interesting route via Cuzco and Macchu Picchu. We head regretfully for the coast, therefore, and reach Camana in the evening. A very long drive, which takes us from 15,500 ft. at the top of the pass to sea-level in a few hours. The Land-Rover is not keen on the change in altitude, and starts running backwards and so on.

Sunday, 9 October - Another long haul, Camana to Lima, getting to Lima at midnight.

Monday, 10 October - A busy day, arranging for the shipment of the Land-Rover to England. The Peruvian AA undertake most of the handling.

Tuesday, 11 October - A day to ourselves at last! Spent shopping and sight-seeing in Lima, and in a visit to the nearby seaside resort of Ancon.

Wednesday, 12 October - Flew from Lima at 07.00 hours, stopping at Bogota (Colombia) and Panama City. Arrived in sweltering Miami in

the evening. Indulged in a midnight swim on Miami beach.

Thursday, 13 October - Left Miami by Greyhound bus in early morning. Long, long, slog through Florida coastal belt. Horrible! Slept through the night on coach.

Friday, 14 October - Arrived Washington about 11.00. A hurried day's sight-seeing around this very beautiful city. Left by Greyhound bus again in the late evening for New York. Dozed on bus for a few hours.

Saturday, 15 October - Arrived at New York at an absurdly early hour of the morning. Slept on uncomfortable wooden benches for a few hours, before being moved on by an exceedingly rude policeman. Day spent sight-seeing around Empire State, U.N. Building, etc. Flew from J.F. Kennedy Airport at 23.00.

Sunday, 16 October - Arrived Reykjavik in Iceland about midday, after an uncomfortable doze on the plane. Bitterly cold after America, but most interesting. Did some sight-seeing, found the cost of living unbelievably high.

Monday, 17 October - Flew from Reykjavik at about 09.00. Stopped briefly in Glasgow, and finally landed at London at about 17.00, after being away exactly 100 days. Very, very mixed feelings about getting back.

# TRAVEL

by

Alan Cope

Our travel arrangements were of necessity a compromise between expense and time. From the outset we appreciated that the major item of our total expenditure would be the travel to and from South America. Consequently it was a relief when Lobitos Oilfields Ltd. generously offered us free sea passages to and from Peru on their tanker "El Lobo". The tanker was scheduled to leave England on 17 June. This was about a week before Peter and Jeff completed their final examinations. It was decided that Tony and I should travel out by "El Lobo" and then drive the Land Rover to Uyuni by way of La Paz. Peter and Jeff were then to take a French Line ship to Buenos Aires and travel by rail to Uyuni, where they would meet us.

The British seamen's strike changed all these arrangements. The manager of "El Lobo" decided, that during the delay caused by the strike, it would be expedient to carry out the ship's annual maintenance. This maintenance was scheduled to take place while we were in the field and it would have taken two to three weeks. Consequently the ship would return sooner for us and our time in the field would have had to have been drastically reduced. It was also out of the question to wait for the next voyage of the "El Lobo" as this would have involved an extension of four weeks with a consequent

wonderful day looking around the capital we left at 1 a.m. to arrive in New York at 6 a.m. Another fine and interesting day in New York prepared us for our overnight flight to Reykavik by Icelandic Airlines. After a day in Iceland we completed the last lap of our journey by Icelandic Airlines to London.

TRAVEL HINTS

1. Travel to and from South America

By Sea

East Coast - Royal Mail Line (1 ship per 3 weeks)
French Line (1 ship per 3 weeks)
(There is a rail service from Buenos Aires to La Paz three times a week, taking 3 to 4 days for the journey).

West Coast - P.S.N.C.

By Air

BOAC to Lima, once per week.

Also, other European airways have weekly flights.

Or, by air to New York and then PANAGRA or BRANIFF to Lima.

By Air and Bus

BUNAC flight to New York (if out of season, Icelandic Airlines single air fare is approximately £10 cheaper than IATA airlines); then Greyhound bus to Miami and Aerolineas Peruanas to Lima.

Or, if BUNAC run a flight to Mexico (not every year) take this flight and then Aerolineas Peruanas to Lima.

termination of our College careers. The only alternative was to fly home and an urgent application for financial assistance was made to the Exploration Board. The Board met our application with a generous response, which enabled us to travel as follows.

The strike and maintenance delayed the "El Lobo" sufficiently long for Peter and Jeff to join us on the "El Lobo" which finally left Birkenhead at 4 a.m. on 12th July. After the pressure of last minute preparations the life on board the "El Lobo" was a welcome relief. There was little to do but to eat, read and sleep. The only exercise we took was by walking from fore to aft for meals and swimming in the ship's pool. Our quarters were excellent as was the quality and preparation of the meals.

The ship stopped at two ports, Cardon, the Shell oil refinery on Lake Maracaibo in Venezuela, and La Libertad in Ecuador. It is sufficient to say that Cardon was not a pleasant place, but our three day stay in La Libertad was very much enjoyed. Whilst at La Libertad we visited Guayaquil, the largest town in Ecuador. This was not a pleasant town, but the journey in a native bus to and from the town was ample compensation.

We arrived at Talara in Northern Peru on 4th August. We were met by the Lobitos representative, Senor Carera, who showed us to a hotel. Senor Carera then efficiently set about the task of clearing our equipment and Land Rover with the customs. The next morning Jeff and I set off for Lima by Expresso Sudamericano bus. Tony and Peter were to follow with the Land Rover and equipment and meet up with us at La.Paz. The journey by bus to Lima took 22 hours

and was surprisingly comfortable and extremely interesting.

Lima greeted us with the low clouds and drizzle typical of winter in Lima. We were well received by Mr. Neville of Lobitos, who ensured that our stay in Lima was both efficient and enjoyable. The next day we travelled by Morales Moralites bus to the beautiful city of Arequipa (20 hours). After a night in Arequipa we caught the train early next morning over the mountains to Puno, and from Puno we caught the overnight steamer across Lake Titicaca. We awoke in Bolivia to a glorious sunrise over the lake. After a crude train journey from the Bolivian lake port, Guaqui, to La Paz, we made the final descent from the Altiplano into La Paz, a memorable experience.

Whilst waiting for the others, we made all the necessary arrangements with Geobol, etc. After the others arrived we carried on to Uyuni. Our travels from La Paz to La Paz are reported elsewhere.

Our journey home from La Paz was to be by train and steamer to Macchu Picchu and then to Lima. However our delay by the customs in La Paz and our retention of the Land Rover gave us no choice but to cut our losses and make direct for Lima. The journey took three arduous days, but was not without interest. The drive around Lake Titicaca, flamingoes on a lake between Puno and Arequipa, and the ancient lines of Nazca partially made up for our disappointment for missing Macchu Picchu.

We left Lima by Acrolinas Peruanas at 7 a.m. arriving in Miami at 7 p.m. There were two stops of half an hour at Bogota and Panama City. After a night in Miami we left by Greyhound bus at 7.35 a.m. and arrived in Washington D.C. at 12 noon the next day. After a

2. Internal Travel

There is a network of regular air flights both in Peru and Bolivia. Fawcett Airlines of Peru and Lloyd Aero Boliviano of Bolivia are the main companies, but they have several competitors. Their prices are reasonable but cannot compete with the cheap surface transport. However the only access to some places is by air.

There is an excellent bus service down the western side of South America from Guayaquil to Santiago. Several bus companies compete against each other, offering almost identical services and charging the same fares. The bus routes extend into the Andes to Cuzco, Puno and La Paz. In La Paz buses may be obtained to all the major towns of Bolivia. Bus travelling is most economical but can be painful.

| | | | |
|---|---|---|---|
| Talara to Lima | 22 hours | 160 soles | £2 2s. 6d, |
| Lima to Arequipa | 20 hours | 165 soles | £2 3s. 9d. |

A more expensive, but still reasonable, way of travelling on the ground is by collectivo. Collectivos are fast taxis which advertise their route by a sign on their roof, and then when full, they follow that route as if it were a grand prix circuit. This is excellent if you are in a hurry and you are brave.

There are few railways in Peru and Bolivia, but those that there are, are reliable. From Lima there is a daily service eastwards via the highest station in the world - 15,693 ft. - to Huancayo. From Huancazo a two-day bus journey may lead you to Cuzco, but be prepared to push the bus. The only other railway in Peru is the Southern Railway from Mollendo on the coast to Cuzco via Arequipa.

There are excellent and cheap meals served on the trains. We took this train from Arequipa to Puno and found it extremely comfortable. From Puno we went by lake steamer across Titicaca to Guaqui in Bolivia and from there by train to La Paz. This journey from Arequipa to La Paz, travelling first-class (this is advisable), took 36 hours and cost just under six pounds each.

From La Paz you can reach Cochabamba, Potosi, Oruro and Uyuni by train. In addition there are regular services to Buenos Aires in Argentina and Antofagasta and Arica in Chile. There is also a dubious rail link with Brazil from Santa Cruz, but this apparently is a major expedition in itself.

# MINING AND MINING GEOLOGY

by

Peter Francis

## Introduction

The stated aims of the expedition were primarily to make a study of the abandoned Spanish silver mines in the area of San Antonio de Lipez in Bolivia. The following pages contain the results of this study. In our original prospectus, circulated to would-be sponsors, we asked two questions: Why have the industry and people moved away? Are the deposits exhausted or could they be worked again today? We are now in a position to offer at least part of the answer to these questions, but inevitably, more and more questions have arisen to be answered.

The report will be in two sections: Mining Geology and Historical.

## MINING GEOLOGY

In this section it is proposed first of all to describe briefly the general geology of Bolivia, on the assumption that most readers will be as ignorant of it as we were; and then briefly mention the geology of the field area in which we were working, and finally a more detailed description of the individual mines visited.

Resume of Bolivian Geology and Topography

The Andes enter Bolivia from the north as two distinct chains, known respectively as the Cordillera Real or eastern range, and the Cordillera Occidental or western range, which are separated by an immense high plateau, the Altiplano. The western range lies principally in Chile and Peru, but its eastern slopes fall within Bolivian territory. The eastern range rises abruptly above the Altiplano, and then slopes off gradually to the east, fading away into a vast plain that extends far away to the eastern boundary of the country.

The average elevation of both ranges is about 15,000 ft; the highest peaks in the west reach nearly 20,000 ft. while those in the eastern range, such as Illimani and Illampu, reach 22,000 ft. The altiplano between the ranges is about 500 miles long and over 100 miles wide, with an average elevation of 12,500 ft.

Geologically, the Cordillera Occidental is made up essentially of volcanic rocks, representing vast accumulations of lavas of rhyolitic, trachytic and andesitic compositions. The peaks are largely dormant and extinct volcanoes; some of them having the very elegant profile typified by Mount Fujiyama.

Folded Paleozoic sediments ranging from Cambrian to Devonian make up the bulk of the Cordillera Real. They are typically shales, slates, sandstones, quartzites and greywackes. These sedimentaries rest on a granitic core which is exposed in the Illimani and Illampu massifs and elsewhere. The granite is probably Devonian.

In Cretaceous times, a second sedimentary sequence was deposited on top of the Paleozoics; this consists mainly of sandstones, marls, gypsum and dolomite. An extensive emergence followed in Tertiary time, together with a period of igneous activity, intrusive and extrusive, though on a much smaller scale than in the western range. Marine fossils of late Tertiary age now resting at an elevation of 13,500 ft. on the slopes of the Cerro Rico at Potosi indicate that part at least of the Tertiary uplift and igneous activity took place in Miocene or Pliocene time.

Paleozoic sedimentation continued on the altiplano until the Permo-Carboniferous, but these are the last marine sediments known in that region. They are transgressed by a great series of terrestrial sediments - red ferruginous shales, sandstones and conglomerates which may range from Triassic to Tertiary in age. Towards the close of this period the region was also characterized by igneous activity - in the west of the altiplano are rhyolitic tuffs and ashes of subaqueous deposition. Extending longitudinally across the high plateau is a belt of diorites and andesites which are probably of the same age or possibly earlier.

The relation between ore deposition and igneous intrusion in Bolivia is striking. The principal gold deposits are grouped around the Illampu-Illimani range in the department of La Paz. The Ag, Sn, Bi, W and Sb deposits show intimate relations with the Tertiary intrusions of the eastern range, and it is generally considered that late Tertiary was the period of greatest mineralization in Bolivia, though the gold deposits may be Paleozoic.

Summary of the Geology of the San Antonio-San Pablo Area

No geological mapping has been done in Bolivia south of Uyuni. What follows is based on observations made in the field, supplemented by information supplied by Ismael Montes de Oca on the likely ages of the principal formations.

The earliest formation present is apparently an early Paleozoic succession of very great thickness, moderately folded but unmetamorphosed. The rocks are principally turbidites, similar to those of Wales, and completely lacking in fossils, which makes accurate dating impossible. An Orovician to Devonian age is likely, by analogy with very similar formations in the Potosi area. This formation is principally exposed in the hills between San Pablo and San Antonio, the track at one point running directly across strike of a steeply dipping succession, clearly very thick.

This succession is overlain with strong unconformity by a flat-lying (Tertiary?) formation, the most conspicuous member of which is a very thick, massive, white tuff which forms magnificent cliff exposures in many river valleys. This white tuff unit appears to be thickest near San Pablo, and seems to increase in thickness southward.

A very large andesite stock is the other major unit. This, although its area is rather an unknown quantity, is exposed all round San Antonio and is the only rock type there. It is generally not well exposed in situ, but forms abundant scree on all the hills around the village. It was quarried in one or two places to provide building stone for the cathedral and all the other buildings in

the village. The age of the andesite is uncertain, but is probably Tertiary.

The regional mineralization is also almost certainly late Tertiary, here as everywhere else in Bolivia, and principally consists of sets of simple veins cross-cutting the earlier formations. An east-west set was extremely common in the field area, and probably represents mineralized fault or joint planes. The major elements appear to be Pb, Zn, Sb, with associated silver. The veins show a very definite zoning from entirely Sb down to mainly Pb in depth.

Oxidization of the primary sulphide ores has played a very large part in the development of silver mining in Lipez, as well as elsewhere in Bolivia. The zone of oxidization tends to be somewhat variable in depth, and in many instances in Bolivia, silver mining was abandoned once the very rich oxidized ores had been exhausted. Many of the smaller mines around San Antonio were probably dug to exploit this enriched ore, while the larger mine systems penetrated into the primary ores, where the sulphide ores still carry high silver values.

The oxidized ores were extremely difficult to recognise, and it is probable that in the field we may have missed some, but on the whole it was our impression that these ores had been removed virtually lock, stock and barrel - there was plenty of typical gangue material - limonite, barite, quartz and so on, but very little trace of the secondary silver mineral cerargyrite or "horn silver" which was the principal ore mineral in the oxidized zones in most of the Lipez mines.

Cerargyrite, AgCl, is bluish to purple in colour, usually formless and associated with more or less limonite and barite. It is not easy to recognise, since it often forms merely a grey to purple film over limonite and other material, and even when massive is neither conspicuous nor impressive. It would be very easily overlooked, especially by people such as ourselves who were unfamiliar with this sort of material.

The primary sphalerite/galena ores were of course very obvious and unambiguous, but it would have been useful to have had some means of obtaining in the field their silver content.

Average tenors for the oxidized ores would probably have been in the order of 150 oz. per ton, while rich ore shoots, by analogy with other areas, could have reached anything up to 600 or 700 oz. per ton - naturally there was no evidence remaining of any such rich ores.

It should be stated at this point in the report that we are seriously handicapped in our work by an absence of data - nearly all the many specimens collected in the field were left in Bolivia for analysis by Geobol. These specimens are still in Bolivia, and no results have been forthcoming, so we are forced to rely on those few specimens brought back by members of the party personally, and on some data provided by Geobol while we were actually in La Paz.

Sampling of spoil tips constituted an important part of our fieldwork, and considerable effort was put into this aspect - this work was not wasted, however, for even without the bulk of our data, it is clear that the tips contain little of economic interest - although some semi-quantitative analytical results by Geobol do show some interestingly high values for cadmium.

If any significant results are obtained from Bolivia, these will be inserted in the report as an appendix, or circulated to interested parties.

In the course of our fieldwork we concentrated on two areas in detail; San Antonio de Lipez and San Pablo de Lipez, establishing camps at both these places. In addition we made several excursions to look at other mines over a wide area. These trips, which were generally of one day's duration, were intended only to get an idea of the extent of the workings and the sort of ore being obtained, and will only be mentioned briefly. They did serve, however, to give a good idea of the general mineralization of the Sud Lipez area. The report will accordingly be in three sections: San Antonio, San Pablo and general.

## San Antonio de Lipez

Our first reaction to the mines at San Antonio was one of disappointment. There were enough of them, to be sure, but the first three we descended had all too obviously been dug in comparatively recent times - with evidence of railway tracks, and even remnants of paper from blasting charges. These mines, which were large, simple adits driven into the hillside, following minute veins, probably belonged to the 1870 phase of operation, or even later - perhaps COMIBOL, and had clearly not made any money, ending abruptly a few hundred feet in. (These mines are marked on Map 1.)

Our spirits changed, however, after a few days when we discovered the Mesa de Plata mine, some 3 kms. north of San Antonio. Although some of the buildings outside were obviously fairly modern, it was immediately clear that these were superficial and the mine itself was an excellent example of a Spanish mine, and a very large one at that. There was even a carved tablet over the very imposing adit entrance, but this was unfortunately illegible. This mine proved to be extremely interesting, and it is proposed to spend the next few pages describing it.

Surface Layout

This mine turned out to be considerably larger than we anticipated and was a mine complex rather than a single mine. Initially we though it consisted only of a single main haulage level, but after working on the mine for some time we realized that many of the surface workings between Misa de Plata and San Antonio were in fact separate entrances to the Mine.

Since many of these small entrances were blocked or too dangerous to descend, we could not establish exactly which entrances led down to Mesa de Plata and which were separate small mines, but it was obvious that a great deal of small rabbit warren mining was taking place, in addition to the well organised effort in Mesa de Plata.

An outline of the surface buildings outside the mine is shown on Map 2. Some of these were undoubtedly of 1870 vintage, with even more recent additions, but the bulk seemed to be genuinely Spanish. Particularly interesting was what we interpreted as a donkey yard, an irregular quadrilateral walled-off area directly above the mine

entrance. The size and layout of the spoil tips are also shown on Map 2. Clearly the most important of these is directly outside the main adit entrance, but there were a great many smaller tips outside the subsidiary entrances. Sampling sites on the spoil tip are also located on this map.

There was no sign of crushing or smelting equipment at Mesa de Plata, but these processes may have taken place in the village of San Antonio itself.

Underground Layout of Mesa de Plata

The main haulage level leads straight into the hillside for nearly one and a half miles in a direction 220°, with minor passages leading off at intervals. The main level then forks, and the two passages then diverge along slightly curving lines. The left-hand passage continues for about another quarter of a mile, before increasing amounts of water and unsafe appearance of the roof discourage further exploration.

The right-hand passage leads on for some hundreds of feet, coming eventually into a very large stope, so precariously proppoed with rotting timbers that one is afraid to tip-toe in, let alone start hammering to collect specimens. Just before reaching this stope, however, two man-ways lead off from the passage, climbing steeply upwards. A noticeable draught was felt beneath these man-ways, strongly suggesting that they led to the surface, very likely at one of the many entrances on the hilltop above Mesa de Plata.

While we were never able to actually enter one of these entrances and leave the mine by the main haulage level, we did explore some of them as far as we could. The man-ways led very steeply down from the surface; very low, narrow and tortuous - a great contrast from the main level, which was almost good enough to drive a 'Mini' along. One of these came out into an enormous stope, far larger than anything we had imagined, and it was clear, from the sheer size of it, that the ore could never have been carried upwards to the surface via the man-ways, but must have been taken down to the main level of the mine by some link up that we could now only deduce.

## Methods of Working

### Conditions

The conditions prevailing underground and on the surface will control to a degree the methods used in working the mine. Two of the most important conditions in this area are the extreme aridness and the bitter cold. This has two very significant results: first, no sort of tree grows anywhere near these mines - the nearest timber suitable for propping must be in the tropical lowlands, some hundreds of miles away. Hence timber would have been at a premium, and used very sparingly.

Secondly, the amount of surface water entering the mine will be negligible - while it was perfectly dry during our time in the area, there is a wet period in December and January, but this is hardly likely to be severe. Drainage, however, is a problem in these mines, as we shall see later, but it seems likely that this is due to connate

water rather than surface water. The extreme dryness of the air does lead to some extremely interesting effloresence compounds growing on the walls of the mines - many of the passages in Mesa de Plata were completed covered in a thick woolly, fluffy mass of very fine, thin crystals - many inches long. These are believed to be mainly ferrous sulphate, but occasionally green and blue minerals are found, almost certainly copper salts - carbonates or sulphates.

In the next few sections it is proposed to describe the ways in which the lack of timber and the water in the mines were dealt with, and to look at some of the other techniques used.

The Use of Masonry

The very first thing to strike even the most casual visitor to Mesa de Plata is the very elegant use of masonry. Mention has already been made of the very imposing adit entrance; the passage beyond is entirely lined along its whole length with roughly shaped blocks. Usually, no morar was used, the blocks were merely keyed together fashion and wedged tightly - a very sophisticated sort of "dry stone" walling. In the deeper parts of the mine, further elaborationswere introduced at the intersections of passages, where a sort of barrel vault technique had been used. This was a really amazing piece of craftmanship.

The emphasis on stonework to support the roof is clearly a reflection of the lack of timber in the area - some pit-props were found and these often turned out to be of a very inferior sort,

probably pieces of the scrubby bush-cum-tree called 'tola' which grows in one or two places to about 6 ft. high. These timbers were always in an advanced state of decay and it was only with extreme caution that we would go anywhere near them. From the immense amount of trouble taken with their masonry, it is clear that the Spanish were at great pains to make their workings safe.

Drainage

All levels in Mesa de Plata, below that of the main haulage level were flooded. It is suggested that this may be connate water rather than surface or meteoric water. As one penetrates deeper into the mine, the temperature rises steadily. Some hundreds of feet in from the entrance, there are large flows of ice and some spectacular ice-pillars, but at the furthest point we could go in to mine the temperatures were considerably warmer and large amounts of water were flowing down the passage towards the entrance.

This water was drained away by the interesting technique of sub-adit drainage. A false floor (stonework again) was built in the driveway, and the water was chanelled off underneath while haulage went on over the false floor. Fig. 1.

There may have been some sort of pumping gear to keep the lower levels dry, but no tangible remains of this were found - the apparatus may have been removed when the mines were abandoned.

Hoisting

Two sorts of hoisting were probably employed in Mesa de Plata:

(a) hand hoisting

(b) donkey hoisting.

(a) Hand hoisting. In this case the ore was lifted via a hand-wound hoist to a level above the main haulage level and then dropped through box-holes to the haulage level where it was loaded into tubs to be carried to the surface. Fig. 2.

(b) Donkey hoisting. A broad flight of stairs leads off to the left from the main drive in Mesa de Plata, and leads into a very large circular chamber about 40 ft. diameter, with various apertures in the walls; one of which opens over a large, deep vertical shaft, now flooded.

This we interpreted as a "donkey chamber" - teams of donkeys presumably plodded round and round the chamber, driving some sort of wooden winch construction which hauled the ore up the shaft. The ore was then carried away via ore chutes to the main haulage level. Fig. 3.

Unfortunately, not a vestige of the original machinery remains - it was probably dismantled when the mine was abandoned, but the Mint in Potosi has some very fine examples of the sort of wooden machinery that was almost certainly employed here.

Donkeys were probably used to haul tubs of ore along the main level as well.

## THE DRAINAGE SYSTEM.

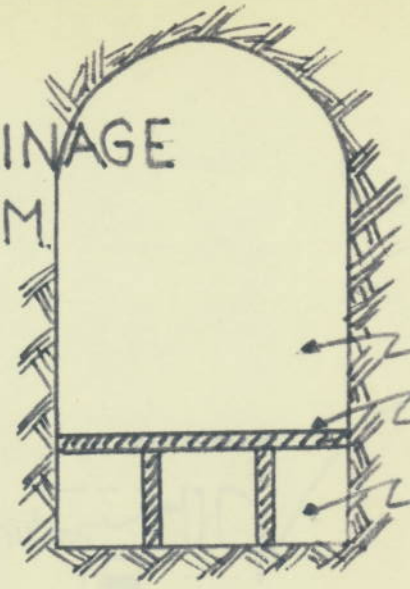



FIG. 1.

## HAND HOISTING

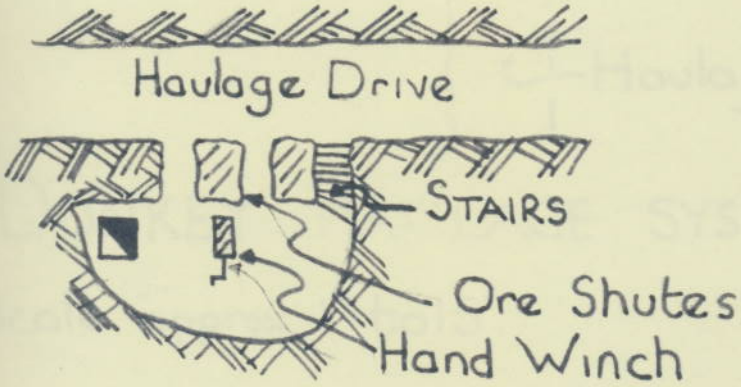
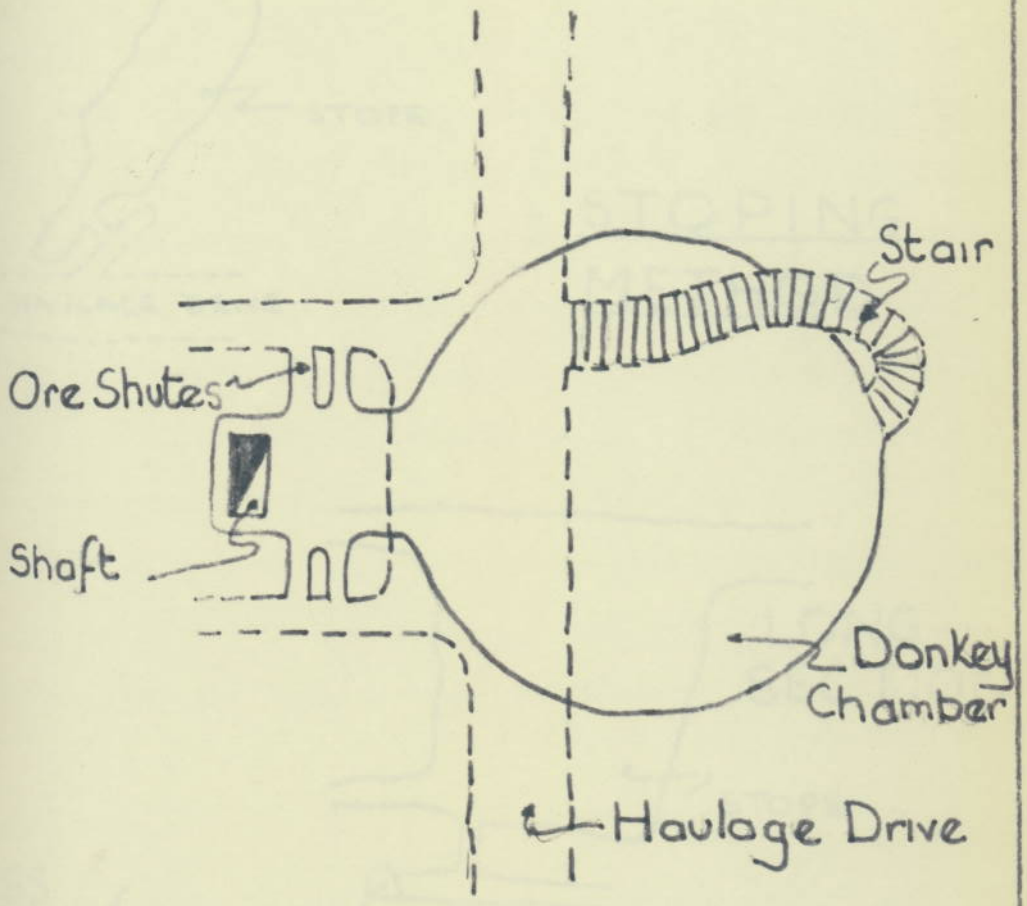



FIG. 2.




DONKEY HAULAGE SYSTEM.

Scale approx 1" to 15'

FIG. 3.

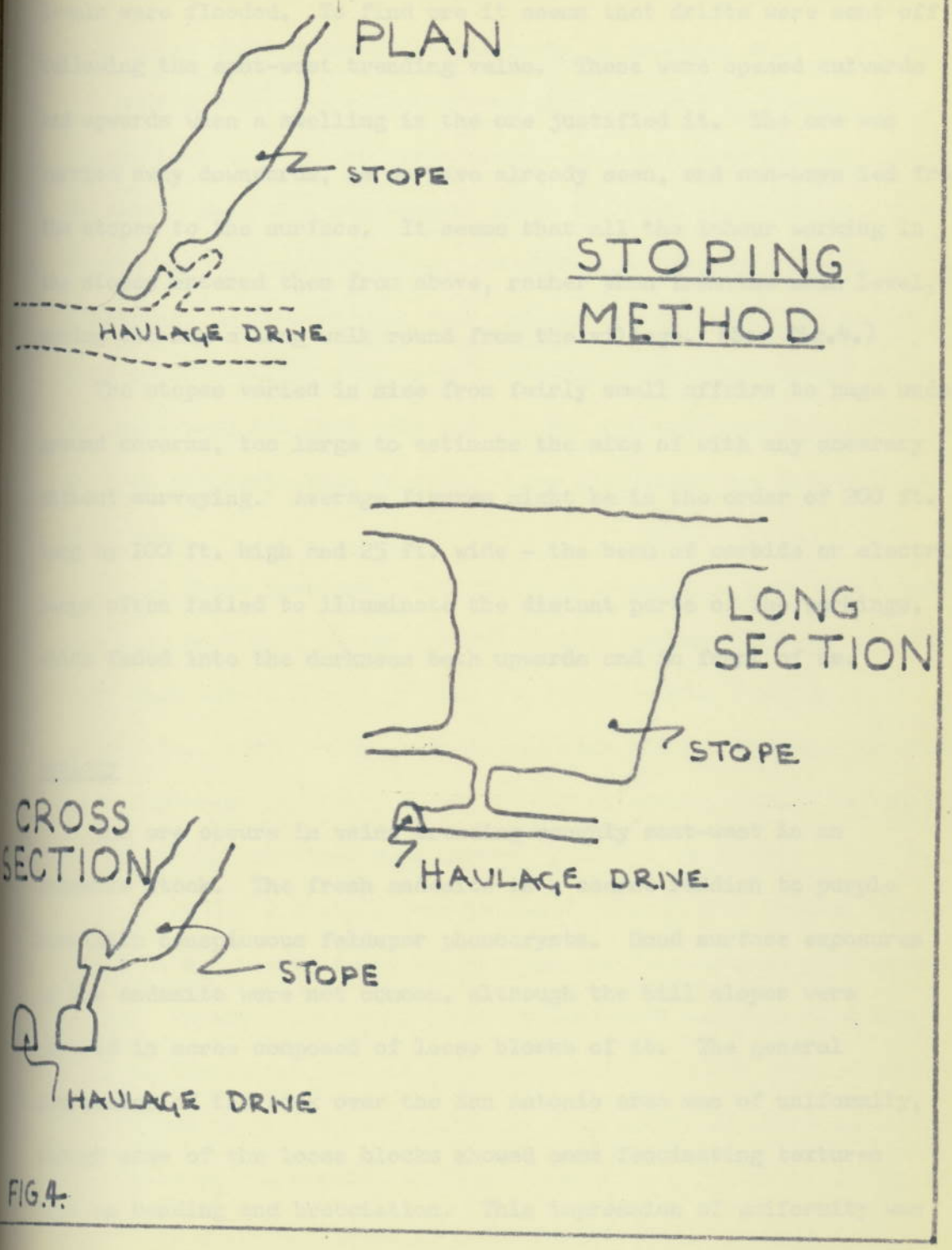

PLAN
STOPE
HAULAGE DRIVE
STOPING METHOD
LONG SECTION
STOPE
HAULAGE DRIVE
CROSS SECTION
STOPE
HAULAGE DRIVE

FIG.4.

Stoping

Only stopes in the upper levels could be studied since the lower levels were flooded. To find ore it seems that drifts were sent off following the east-west trending veins. These were opened outwards and upwards when a swelling in the ore justified it. The ore was carried away downwards, as we have already seen, and man-ways led from the stopes to the surface. It seems that all the labour working in the stopes entered them from above, rather than from the main level, saving the men a long walk round from the village. (See Fig.4.)

The stopes varied in size from fairly small affairs to huge underground caverns, too large to estimate the size of with any accuracy without surveying. Average figures might be in the order of 200 ft. long by 100 ft. high and 25 ft. wide - the beam of carbide or electric lamps often failed to illuminate the distant parts of the workings, which faded into the darkness both upwards and in front of us.

Geology

The ore occurs in veins trending roughly east-west in an andesite stock. The fresh andesite is a coarse reddish to purple rock with conspicuous feldspar phenocrysts. Good surface exposures of the andesite were not common, although the hill slopes were covered in scree composed of loose blocks of it. The general impression of the rock over the San Antonio area was of uniformity, though some of the loose blocks showed some fascinating textures such as banding and brecciation. This impression of uniformity was

confirmed during an ascent of the Cerro de Lipez where very good fresh andesite composed the entire mountain. Here again, though, there was hardly a single block that could be said to be definitely in place - the whole mountain seemed to be an enormous pile of scree.

Underground, the situation was also difficult. Mention has already been made of the efflorescence products covering the walls of the mine. When this was scraped away, the rock behind was still heavily altered and was generally soft and extremely crumbly - it was not easy to distinguish between wall rock and ore, except where the latter showed up as a particularly dark brown rusty material. Some decent hand-specimens were obtained underground, but the most useful material was found on the spoil-tips outside, where everything was perfectly dry and fresh.

From these specimens, and others obtained from many small mines near Mesa de Plata, it was deduced that the primary ore was galena, associated with a little pyrite, but conspicuously lacking in sphalerite. Some specimens suggested that the ore formed a mineralised fault-breccia in the andesite, others simple veins. The oxidised ore typically contained much quartz, limonite and barite - the barite often in good cox combs. Some specimens showed good banding textures of quartz and haematite, other had vughs containing good amethystine quartz. We were disappointed not to find much evidence of silver minerals themselves, but it is probable that all the "easy money" had been picked up by the generations of prospectors who have picked over the tip-heaps and scratched around underground, hoping to strike it lucky, and as usual, going away empty-handed.

Unfortunately, no useful specimens from Mesa de Plata are available, nor do we have any spectrographic data from Geobol.

## The San Pablo Area

The San Pablo Area is situated about 20 miles directly north-east of San Antonio. The mines proper are situated about 7 km. south-east of the village in a deep valley cut in a whitish tuffaceous rock. There are three mines in this valley; Buena Vista mine, at a height of 4,500 metres, which was perhaps the most important, with workings believed to extend to a depth of about 1,000 ft.

Three hundred metres south of Buena Vista is San Juan mine, much smaller and probably not as deep. This mine was particularly interesting in that it appeared to be the one with the most economic possibilities in the whole area. Another 1,200 metres south of San Juan and about 300 metres up the valley side is the third mine, Leoplan mine. This is a working antimony mine, employing about 20 men, and while originally Spanish(?) has been worked since June 1966. The manager of this mine, Senor Arias, apparently worked for a larger concern, which held the mining rights for the whole valley and before we were able to look at any of the mines we had to pay a visit to Bolivar mine some 30 miles away to get a document of authorisation. To come across such a piece of bureaucracy in such a remote area far away from the reaches of civilisation was amazing, not to say frustrating. These three mines are shown on the main map.

It is proposed to describe each of these mines in turn under broadly the same headings as before.

Buena Vista Mine

Surface Layout

The plane-table survey of this area is shown in Map 3. The most conspicuous features on the surface are the large and numerous spoil-heaps on the valley sides. These were apparently all of the same general age, in fact apart from the current activity in Leoplan mine, these mines seem to have been neglected since their original abandonment. Just outside the entrance to the main haulage level of Buena Vista were a group of buildings, now in ruins. What these ruins were is now difficult to interpret; some of them may have housed crushing or smelting plant, others were probably accommodation for the miners.

Some of these were so small and cramped that it must have been impossible to swing the metaphorical cat, but they must have housed at least one or two men, and each room was complete with a tiny stove in one corner. The donkeys must have had some room - their yard was by no means as big as that at Mesa de Plata but it was of generous proportions. In addition to this outdoor accommodation, there was also an underground stable for the donkeys, a short way down the main adit. This was complete with a feeding trough carved out of the rock and running the whole length of the chamber - it seems that in this case the Spanish thought more of their donkeys than of their men!

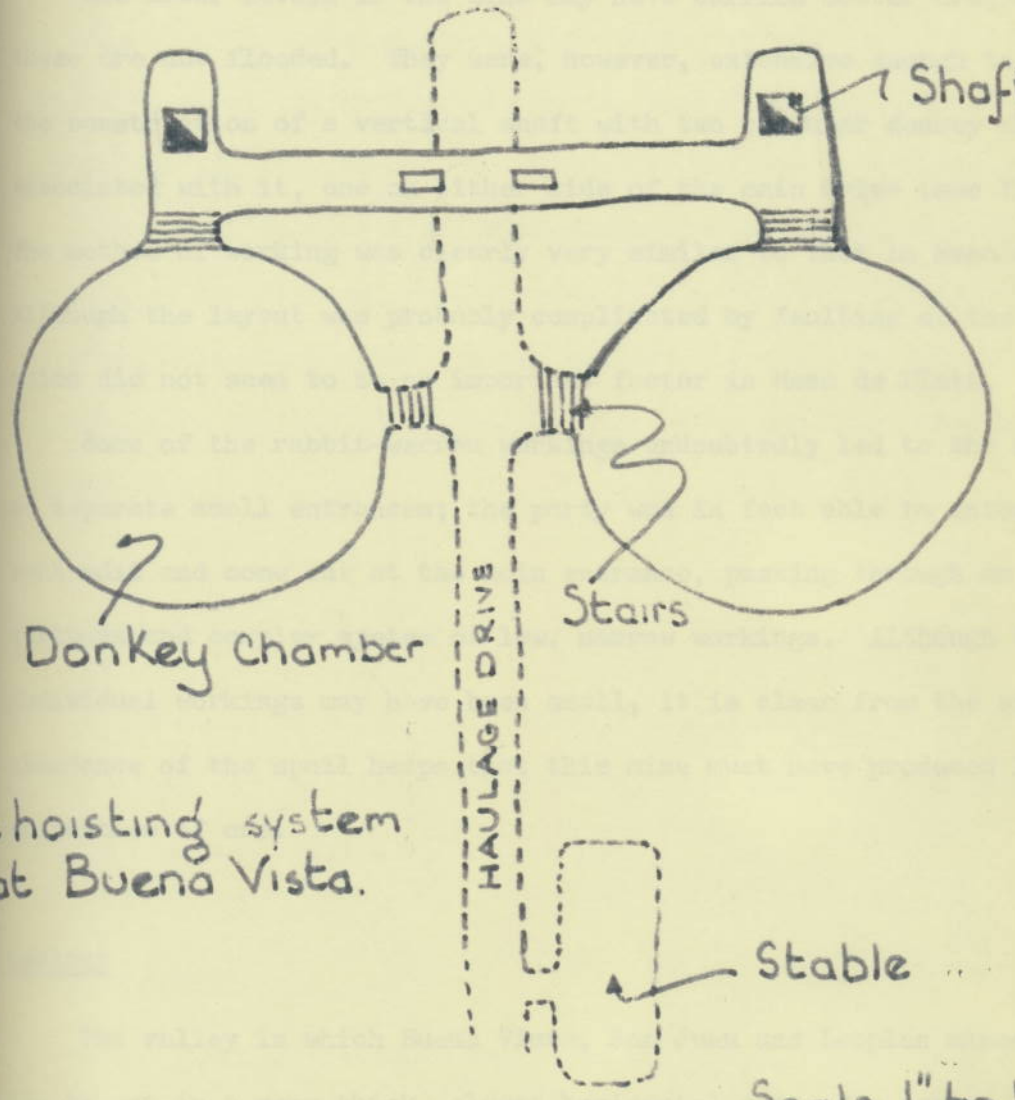
Of particular interest also were the numerous minor entrances to the mine - these were steeply sloping, tortuous man-ways very similar to those leading in to the stopes at Mesa de Plata. There were also

one or two vertical shafts nearby, which on the time-honoured test of dropping a stone and counting, sounded awfully deep and were flooded. Counting suggested a depth in the order of 600 ft. to the water - enough to be terrifying, especially when the shafts were completely unmarked and unprotected. Near one such shaft was a Spanish built wheel-house, obviously used for hoisting ore. A conduit led directly uphill from this wheel-house to a sort of chimney on top of the hill (Map 3 ). This suggested that some sort of water power might have been used to drive the winding-gear, but in such on arid climate this seems unlikely.

Other conduits were also found near the surface buildings, and these in places were seen to be linked with various small cisterns which must certainly have been used as settling tanks of a sort, to separate heavy ore from lighter gangue. Exactly comparable installations were seen still in use at the Santa Isabel tin mine, mentioned later on.

Underground layout

The entrance to the main adit in Buena Vista was not nearly so imposing as that at Mesa de Plata. The first feature encountered is the underground donkey chamber mentioned above; the main drive continues for some way beyond this before the passage is terminated in a blind face - perhaps a fault. Many small workings branch off from this main drive, however, and the rabbit-warren nature of these workings are a great contrast from the large scale of operations in Mesa de Plata. This is perhaps a reflection of the smaller sizes of




The hoisting system at Buena Vista.

Fig. 5.

the veins, which did not warrant the enormous stopes found in Mesa de Plata. We were able to identify the working faces, and to confirm the thinness of the veins - often only an inch or two.

The lower levels in the mine may have carried better ore, although these are now flooded. They were, however, extensive enough to warrant the construction of a vertical shaft with two circular donkey chambers associated with it, one on either side of the main drive (see fig.5). The method of working was clearly very similar to that in Mesa de Plata, although the layout was probably complicated by faulting of the ore, which did not seem to be an important factor in Mesa de Plata.

Some of the rabbit-warren workings undoubtedly led to the surface at separate small entrances; the party was in fact able to enter one such adit and come out at the main entrance, passing through an extremely tortuous and complex system of low, narrow workings. Although the individual workings may have been small, it is clear from the size and abundance of the spoil heaps that this mine must have produced large quantities of ore.

Geology

The valley in which Buena Vista, San Juan and Leoplan mines all lie is cut in a very thick, almost horizontal mass of a coarse, unbedded, white tuff. This tuff must be extremely thick, since the walls of the valley rise nearly two thousand feet above the valley floor, and are cut in tuff all the way up. Driving into the mining area one can very easily spot what must have attracted the first Spanish prospectors - the white cliffs are cut by a series of faults or joints,

clearly mineralized, since they weather out very distinctively into rusty brown streaks running up the valley sides.

These veins form a very distinctive set, trending nearly east-west and vertical. The ore is best developed on the west side of the valley, where most of the mining activity is concentrated. All three mines are developed along the same set of veins, though Leoplan mine is very much higher up than the others, and shows a very different mineralogy.

Specimens collected in Buena Vista mine showed the ore to consist of galena, sphalterite, pyrite and a little chalcopyrite and antimonite in a predominantly quartz gangue, but unfortunately no specimens are available in England at the moment, nor do we have any other data from Geobol.

## San Juan Mine

This mine, although comparatively small, turned out to be extremely interesting, in that it appeared as the mine with the most promising economic possibilities.

## Surface Layout

The principal features are shown on Map 3. The only building of interest was a long, low structure with a chimney at one end, and a sort of hearth at the other. This we interpreted as some sort of smelter, perhaps for roasting the sulphide ore. There was also a small square structure on top of the nearby hillock whose purpose we could not fathom, and could only suggest that it was either

unfinished, or was intended to serve the same purpose as the chimney-like building described above Buena Vista.

Underground Layout

This was fairly straightforward. A horizontal haulage drive led in for about 200 feet, into the worked area, where winzes led down to lower levels. All these workings were in the ore body itself; the floors and ceilings were of ore, and many of the passages ended blind in ore. No attempt at stoping had been made, the passages were simply driven horizontally into the ore, in a series of levels, one above the other. The logical next step in working this mine would be to extend the present levels and then stope up from one to the next above and so on.

Geology

This mine, as was stated before, is developed in the same family of east-west veins as the other mines in the valley. Only one vein has been worked in this mine, an extremely rich ore never less than 15" thick composed almost entirely of sphalerite and galena. There is a great deal of ore lying outside the mine, and some fragments from here show very good, large cleavage fragments of sphalerite, which seem to be a low iron variety, judging from its honey-yellow colour. Even better material was obtained underground, and a few of these reached England - they show large amounts of sphalerite, in crystals up to 2 inches across, intergrown with galena and a little chalcopyrite,

with no gangue material at all. Some of the galena is clearly altering to cerussite, otherwise the material is quite fresh.

Spectrographic data on this material, in so far as it can be trusted, is interesting. The galena/sphalerite intergrowth carry in the region of 0.1 - 0.2% silver, this being almost entirely in solid solution with galena rather than sphalerite. (Portions of galena and sphalerite were analysed separately.) Cadmium, interestingly enough, also seems to be present in excess of 0.1%.

It seems, therefore, that this mine is an excellent economic proposition and conversation with Senor Arias suggested that his co-operative might start working it.

## Leoplan Antimony Mine

Since this mine is currently being worked by a handful of men, our examination was restricted to a conducted tour, led by the mine foreman, Senor Arias.

### Layout

The mine is situated very high up on the east side of the valley, and a long, hard slog is required to reach it. There are no buildings outside the mine, which is a simple adit entrance opening out on to a spoil heap. Llamas grazing nearby were said by the foreman to be used to carry the ore down to the valley below, when there was sufficient to warrant it.

Underground, the mine was rather similar to San Juan mine in layout, but there was no evidence of the elaborate Spanish use of masonry. Since there was hardly likely to be a significant demand for antimony in colonial times, it seems this mine must date from a later period - the present operations merely represent a re-opening of earlier works. It is possible that the mine was first developed in the hope that silver minerals would be found, abandoned when the ore turned out to be uninteresting antimony, and re-worked when antimony itself became economically worth while.

Method of working

Passages have been excavated along the east-west trending veins, which are usually only an inch or two thick. Working is taking place at several levels, with winzes leading from one to the other. Passages are generally 4 - 5 ft. high, and 2 - 3 ft. wide. No proper stopes are developed, but the ceiling is raised where the ore is particularly rich.

Working is very primitive. Shot-holes are drilled by hand:- hammers on long cold-chisels. Explosive is inserted, blasted, and the broken rock is reduced by hand, underground; the ore is collected in coarse-woven llama wool sacks and carried to the surface. The gangue is removed separately. Frequently, fracturing takes place along the veins, leaving the wall smeared with ore - this is chipped off by hand with hammer and chisel. The production seems to be in the order of one sack of ore per man per day. The ore is sold to the Mineral Bank of Bolivia, although how it is transported to Uyuni is an unanswered problem.

Geology

The same set of east-west trending veins that are worked in San Juan and Buena Vista mines are mined in Leoplan mine. The wall rock remains the same, but the ore has changed to antimonite pure and simple. The antimonite occurs usually as a blackish uninspiring dissemination, but often radiating clusters of brilliant crystals are found on the slabs of wall-rock.

Less often, magnificent euhedral crystals are found growing into vughs. These provided really excellent specimens, nearly 6 inches in diameter and would be a credit to nearly any mineral collection. Some excellent specimens were obtained by the party.

Very little trace of any other minerals occurring with the antimonite was found, apart from some very insignificant pyrite. It seems probable that a short of mineral zoning is developed in these veins, ranging from antimonite in the east (Leoplan) through galena and sphalerite at San Juan to predominantly galena in the east (Buena Vista).

Other Mines

These will be briefly described, in order of visiting.

Bolivar Bismuth Mine

This mine lies some 25 miles south east of San Pablo, and is reached by a mountain track which offers some splendid views over magnificent scenery, which was unparalleled by anything in the

party's experience; even our Bolivian geologist said that he had never seen anything quite like it.

The first mine reached on this spectacular road is San Salvador mine; we did not go underground here, but were shown around the processing plant. This is fairly sophisticated by Lipez standards, and includes a primitive shaking-table run off an old car engine. This mine also boasts a single lorry, dating back easily to the 1930s but still going well enough to make the arduous 140 mile journey to Uyuni with a load of ore. This happens only once a month or so.

Bolivar mine itself lies some miles further along the road, which is here extremely tortuous and clings perilously to the steep mountain side. The imposing adit entrance indicated immediately that this was a Spanish mine, built with very fine use of masonry. The main drive is equipped with rails and hand-pushed tubs to remove the ore. Manways zig-zagged down from the main drive to various working levels, which were developed along a system of faults trending roughly east-west.

The ore occurs in a vein or veins about 6 - 9 ins. thick, and consists of bismuthinite with accessory chalcopyrite. No stopes were developed in the ore; levels were connected by small vertical shafts up which sacks of ore were hauled by hand. The only implements used in the mine seemed to be hammers, chisels, shovels and wheel barrows; the ore is processed at the surface by hand, by a mixed team of Indian men, boys and women, the sorting into sizes being done in the same order. The final stages are done by a pair of bowler-hatted Indian women sitting cross-legged side by side; each has a hammer

and a flat slab of rock in front of them. They select a lump of ore, break it on the rock into fingernail sizes, and pick out the bismuthinite by hand. This concentrate is then removed to San Salvador mine where chalcopyrite is separated off on the shaking table. The resulting valuable concentrate is then collected up and laid out on mats, raked out and dried in the sun. The ore is sold to the Mineral Bank of Bolivia.

Mestizo Antimony Mine

This mine is located some 10 miles west of San Antonio. Unfortunately, the track stops about two miles short, and there is a long, hard slog up from the valley to the col where the mine is situated. This was by no means an old, or even an important, mine; it seems to have opened by Comibol in the recent past and abandoned soon after.

The mine is a simple horizontal adit, not more than 40 ft. long, branching internally. The mine is already partly collapsed, and it is quite likely that the entrance will soon be completely blocked. The ore seems to have been a rather insignificant quartz antimonite ore vein, which could not have lived up to the prospector's expectations. There was a spoil-heap outside, but this was very small and mostly gangue quartz.

Altogether, the mine did not really justify the long walk in the bitter wind. Another mine, Nuevo Mundo silver mine, was reputed to be some miles further along the same track, but we decided that in this case the effort involved would be too great, particularly since

our Indian guide seemed rather uncertain of his geography. This was a pity, since Nuevo Mundo is the ore mine in the San Antonio area that is mentioned by Padre Barba, and it would have been interesting to locate this mine and see to what extent this particularly inaccessible deposit had been worked.

The Escala Mines

Escala is situated some miles north of San Antonio, and is roughly at the point where the Uyuni-San Antonio road forks to San Pablo. The mines are located some way up a minor valley to the east, and are not easy to find. There are two mines in this valley, both being worked on a pathetic scale; one is working a primary lead ore, the other a secondary copper ore.

(1) Mineral de Escala

This is developed in two separate Pb/Zn veins which are approached by two separate, steeply inclined shafts. The ore is a simple sphalerite/galena assemblage, with a little pyrite, and is very similar to that worked in San Juan (q.v.). A handful of people are employed in primitive hand sorting and screening of the ore, under the supervision of the foreman.

(2) Escala Malachite Co-operative

The mine was developed in a set of steeply dipping veins, 6 - 9 ins. apart consisting mainly of malachite, with occasional signs of cuprite. Again, only a few men work in the mine, about which they seemed to be

rather reluctant to talk, although they did claim to be getting 23% copper in the ore. Production is very small, in the order of a couple of hundredweights per day. The ore is, as usual, sold to the Mineral Bank.

It is interesting to digress here on the system by which these tiny mines are run. It seems that a group of up to 20 or so get together in a co-operative, and pool their efforts and share any profit. This is obviously better than having single individuals or familiar scratching about, but even so the standard of living of these people is pitiful in the extreme - all the families are involved in crushing and sorting the ore, and all live together in tiny little huts or dug-outs, in many cases little better than caves. There are signs that the ore is bringing in cash, however, for bicycles were not uncommon, and seemed to be the only sort of transport freely available. Riding a cycle on the soft, deep sand of many of the altiplano tracks would be a considerable hardship to most, but the sturdy little Altiplano Indians seem to accept it and cover very large distances on their cycles.

Santa Isabel Mine

This mine has a very long history. It was originally opened by the Spanish, and is mentioned by Padre Barba as a flourishing silver mine. At some later stage, probably towards the end of the nineteenth century, it was worked for tin. There is plenty of evidence for this later phase of activity, in the form of broken, derelict pieces of

winch gear and rusting iron wheels from tubs or skips. Some of the surface buildings also probably date from this era.

The mine is being worked today, by a very small co-operative, a mere shadow of what must have been very intensive activity - there are very large spoil tips, some vertical shafts, complete with remnants of winding gear, and a very big, wide adit going an unknown distance underground.

The mine, which is 14 km north-east of San Pablo, is at the base of a high mountain, Santa Isabel, 5,100 metres, which Ahlfeld states is similar in profile to the Cerro Rio in Potosi; the mineralization is in nearly vertical veins, trending roughly west-east, containing mostly pyrite with some blende. The spoil heaps outside the main entrances consist almost entirely of massive pyrite gangue, often with good euhedral crystals.

Very much higher up the mountain where current activity is principally centred, the veins contain a very fine grained yellowy cassiterite, which is mined and concentrated by the small co-operative. It is unlikely that significant amounts of ore are being produced at the present level of working.

HISTORICAL

One of the four bells in the belfry of the Cathedral in San Antonio de Lipez is dated1720. This gives us an excellent idea of the date at which the town was flourishing - cathedrals are not built and sumptuously decorated in new mining camps, nor in declining towns. Silver mining had been going on in Southern Bolivia ever since 1545, when the fabulous "Cerro rico" was discovered at Potosi by the Conquistadores, but it is more difficult to give a date to the start of operations at San Antonio de Lipez.

According to Ahlfeld, this important silver mining area was discovered before Potosi and is thus one of the oldest mining areas in Spanish America, older even than Porco and Oruro.

However, Padre Barba, in his classic "Arte de los Metales" written in the "Imperial Village" of Potosi in about 1637 makes absolutely no mention of San Antonio, even though he mentions as important mines those of Santa Isabel, Todos Santos, San Cristobal and others, all of which are within striking distance of San Antonio. He does make an important reference to the mine Neuvo Mundo, which is very near San Antonio, just behind the Cerro de Lipez. This mine he states to be very good, and newly opened.

This leaves us with a paradox, since Ahlfeld refersfrequently to "Arte de los Metales" and must be familiar with other of Padre Barba's works. The only apparent solution is that although the mines may have been discovered before 1545, they may not have been worked on a large scale until much later on - perhaps over 100 years

later on. This seems reasonable for two reasons. First, the discovery of the huge deposits at Potosi would have effectively diverted most of the attention to that area.

Secondly, the climate at San Antonio is such that the mines would only be worked when all likely cliams in pleasanter areas had been worked - a last resort in fact.

To sum up, one can visualize, in the period around 1540, a great deal of prospecting being done all over the areaconquered by the Spanish. Reports of discoveries filter in from all over this enormous desolate area. Potosi is seized upon as one of the greatest mineral discoveries the world has ever known. Only after sometime has elapsed and Potosi is firmly established do the Conquistadores look elsewhere for more silver to add to the fabulous quantities already being sent to Europe.

It is worth digressing here to comment on the diligence and perseverance of the early miners. As Ahlfeld comments in his book "Yacimentos Minerates del Bolivia", "Ninguno de los yacimentos de plata de Bolivia escapo al ojo avizor de los mineros espanoles." Every single deposit, big or small, was discovered and worked, even those in the highest and most inaccessible mountains. On our excursions in Sud Lipez, we had opportunity to observe this for ourselves, and were continually amazed to find small, long abandoned mines high up the side of mountains and miles from anywhere else. How the miners survived the bitterly cold climate, and supported life where nothing will grow and there is only dry grass for fuel is a fascinating problem.

To say they were hardy is to understate the case, for they must have had a mental toughness as well, for existence in these areas can never have been less than an ordeal. Even in Potosi, lower and somewhat warmer, it was 150 years before the Spanish had become sufficiently adapted to the climate to bear children - previously, they had had to go down to the valleys in order to raise a family.

However, to revert to the history of San Antonio. Mention was made that the town was flourishing in about 1720. When, and why, did the town effectively die?

While it is probable that the town went down with a whimper rather than a bang, we do have a couple of dates to work on. The downhill slide may have started in 1780, which was a year of civil unrest throughout Bolivia. The War of Independence shortly after saw the end of the colonial administration of the country, and more particularly, the mines. Newly independent countries tend to be somewhat erratic and unstable, as we can see in many countries today! The War probably was the chief factor for San Antonio's decline and we know nothing further about it until 1870, when there was a major attempt to re-open the main mine, Mesa de Plata.

We saw some evidence for this phase of re-working in our examination of Mesa de Plata - additions to some of the mine buildings, and, underground, evidence of railway tracks for tubs of ore and remains of pieces of plant underground. This phase of activity ended in 1874, according to Ahlfeld, and this is the last episode of intensive activity we know of.

An abortive attempt to re-open the mine was made by COMIBOL in about 1960 - this party was probably responsible for the corrugated iron sheeting found on some of the old mine buildings. It is not thought that significant quantities of ore were obtained in this period. Comibol or independent prospectors must have examined some of the other workings near San Antonio - a surveying peg was found in the ground opposite one group of mines, which also had numbers painted outside, as though they had been catalogued.*

From conversations with different people, it was clear that many individual miners, or small groups, armed with pick and shovel have tried their luck in the mines, but have gone away none the richer.

This is about as much as we know about the development of the mines in San Antonio. A great deal more could probably be found by a study of the writings of Padre Barba and other early authorities, but this requires access to very rare books and records in Potosi and Seville, and a working knowledge of 17th century Spanish. A purely archaelogical expedition would also reap rich rewards in San Antonio, which must be lying just as it was left, nearly 200 years ago. The Cathedral itself must be nearly unique in being unaltered and unchanged in that period.

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* A mining enterprise under the direction of a certain Zabrisky is known to be working in the San Cristobal area, and to have worked on at least some of the mines near the Mesa de Plata.

Note on the processing methods employed at San Antonio

Following the removal of the ore from the mines, it was subjected to three processes of which we have tangible archaelogical evidence in San Antonio: crushing, amalgamation and smelting.

Crushing

This operation took place in several stages, tending towards progressively finer grades with sorting of the ore at each stage. The first breaking-up of large lumps was done by what we shall call "boulder crushers". These crushers consisted of a large, flat slab of rock (andesite) on which rested a large rounded boulder with a semi-circular profile to its base. This boulder was merely rocked back and forth on the slab beneath, and when sufficient momentum was obtained, the lumps of ore were inserted under the descending face of the boulder.

A splendid example of such a crusher was found at Macchu Socavon, and the principle of its use was easily demonstrated with small lumps of rock which broke easily. San Antonio itself seemed to have a very large communal crusher, the flat slab of which was no less than 10 ft. across. It is probable that several boulders were used on this slab simultaneously; a couple of the distinctive rounded boulders were found very near by. These boulders had deep holes in their tops; it seems clear that poles had been inserted in these holes in order to get more leverage for the rocking motion.

The next stages of crushing were almost certainly done by hand, in exactly the same way as we saw at Bolivar mine. Around San Antonio, we found a great many slabs of rocks with a deep depression worn in the centre; these slabs had probably been used as hammering blocks, on which the small pieces of ore had been reduced to the finest sizes by hand, continual use wearing down the centre.

Amalgamation

The process of amalgamation of the silver ore with mercury is one about which we know very little. The only evidence we have for it is certain blocks of rock containing numerous dish-shaped hollows, rather like a cake baking tray. One example had nine of these hollows, others more. It seems that the finely-ground ore was intimately mixed with the mercury in these, but the actual process remains a mystery. Padre Barba lays great stress on mercury amalgamation in his text, and frequently emphasises the need to reduce mercury consumption and prevent all possible losses. The large quantities of mercury which were required came from Huancavelica in Peru, many hundreds of miles away, and was clearly a very expensive commodity.

Smelting

The smelter in San Antonio is in ruins, as are most of the buildings, but it is still easily recognisable from its three hearths and squat, tapering, truncated pyramid lines (see photograph). Excavation in the floor of this interesting building revealed the sand-

beds into which the molten silver was presumably run into moulds, but very little in the way of artifacts.

Fuel to run the smelter must have been a problem - there are two materials, and two only which could have been used in this area - the dry, spiky, tufty altiplano grass, and dried llama dung. The latter was probably favoured, but must have been in very short supply and commanded a good price.*

After smelting and casting into small ingots, the silver was removed by slow-moving llama trains to Potosi, an extremely arduous journey of some 250 miles, which must have taken many days. At Potosi, where the Imperial Mint "Casa de la Moneta" is housed, the silver from San Antonio and other districts joined the fabulous amounts being extracted from the Cerro Rico, and then begun the long journey across land and sea, eventually reaching the coffers of Spain.

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* In the San Antonio area, tola bushes are very scarce, perhaps due to the altitude, but tola may have been imported as fuel from neighbouring, rather lower parts of the Altiplano, again by llama train.

Simple working out of the richest, oxidised ore is one possibility, combined with probable flooding problems in the deeper levels. There may also have been a drop in the price of silver towards the close of the 18th century, though we have no reliable data on this important factor. There may have been an over-production of silver in Bolivia, with so much easily mined ore about, and consequently only the richest, most easily worked mines could have kept going.

Now the second question: could the mines be re-worked? The answer to this is simple. Yes, they certainly could be, and, as we have already seen, some are in fact being worked, although only on a pathetic scale.

Not only is there probably good enough silver ore in some of the mines to be economically workable by modern methods, but also many other elements as well - we have already mentioned interestingly high cadmium values in San Juan mine.

Further work in the area would be useful to reveal how much ore of workable value remains, and a study of the ore for its more valuable minor elements such as cadmium would be most instructive. Any would-be developer should be warned, however, that the main problems of hostile environment, inaccessibility and shortage of labour still apply, and that while some of those mines inspected did seem to have ores of reasonable tenor, these may be only in relatively insignificant amounts. Much work remains to be done on this subject but it should be pointed out that there has been more than one unsuccessful attempt to re-work many of the mines and the developers have gone away none the richer.

## CONCLUSIONS

We are now in a position to answer the two questions posed in the brochure, and in the introduction to this section.

First, why have the mines been abandoned and the population moved away? There are a variety of reasons for this, all acting together:

(1) The civil unrest and the breakdown of the Colonial Spanish administration, culminating in the Wars of Independance. Miners have always formed the most active and important political element in Bolivia, and it seems probable that they were as active in industrial unrest then as they are now, since, apart from the Army, they constitute the only bodies of men big enough and united enough to make their demands felt.

(2) Transport. San Antonio is so extremely remote and inaccessible that the problem of getting the silver to Potosi must have presented a continual headache, even to the exceedingly industrious and competent Spaniards. To get a llama train from San Antonio to Potosi would take very nearly a month. Apart from this, there was the problem of supplying the town and its people with food, and most important of all, fuel.

(3) The physical hardship. The frigid climate and lack of food and fuel would not encourage one to linger in San Antonio. The literature suggests that there was an exceedingly high death-rate amongst the miners, which need not surprise anyone.

(4) Geological. Several factors probably played a part here.

To conclude, those small co-operatives which are still scratching away for elements such as bismuth, antimony and so on, will probably be able to scrape a living for a good many years to come, but unless a really well organised concern with plenty of money moves in, it looks as though San Antonio will remain a ghost town, empty and desolate in the chill Andean air, and the mines, which once echoed with activity will remain silent and abandoned, until they gradually collapse and disappear from the surface of the earth and from the minds of men.

# BOTANICAL REPORT

by

Alan Cope and Peter Francis

A botanical project was undertaken by the expedition at the request of the Royal Botanic Gardens, Kew. Mr. D.R. Hunt, the South American specialist at Kew, provided much valuable help and instruction, and we were supplied by Kew with two Venesta boxes containing plant presses, drying and preserving materials.

The climate of Sud Lipez ensures that only a few of the hardiest plants survive, the hills being covered for the most part with sparse, dry grass "yata", which grows in fairly large spikey tufts as a rule, but occasionally is found growing in ring formation.

Apart from yata, the only other abundant plant is "tola", a small bush or shrub which rarely exceeds three feet in height. Tola is used extensively as a fuel, since it is the only form of wood on the altiplano, but is much less hardy than yata grass which extends to quite considerable altitudes.

Also worthy of brief notice are the fairly common, small cactii, and a most interesting moss-like plant named yareta, which looks like a very hard, green sponge sprawling over the rocks and exuding a yellowish resin. Yareta is in fact not a moss, but is related to the parsley family, and is sometimes used by the Indians as fuel.

These were the most conspicuous plants in the very sparse, stunted vegetation. In all, we were able to collect 39 species; many, however, represented by only a few specimens, due to their scarcity. Since, however, none of the members of the party were botarists, we could do little else apart from collect and press the material, and make appropriate notes. The specimens are now at Kew awaiting identification, but preliminary results suggest that most of the flowering plants collected belong to the Compositae, while Gramineae, Oxalidaceae, Cactacea (Opunta) and Umbellifera are also represented.

We await the full results from Kew with interest.

# METEOROLOGICAL PROJECT

by

Alan Cope and Peter Francis

Although meteorology was only intended to be an ancillary project on the expedition, it proved to be rather less successful than we had hoped. This was mainly because of lack of time in the field, and because we could not stay in one place for extended periods. Meteorological data only have real significance when taken regularly at the same point over a long period, consequently our data can only give a limited idea of weather conditions.

We had heard tales that temperatures in San Antonio dropped to -30°F at night, and one of the things we wanted to do was to establish first how cold it could get, so as to form an idea of what sort of conditions the Indian miners had to put up with, bearing in mind the lack of fuel and warm clothing amongst the people of the area.

We did in fact find that although temperatures often dropped to 10°F, the most unpleasant feature of the climate was not merely the temperature, but the desperately cold, bitter winds which swept up from the Altiplano.

Although we were in the field in the latter half of the Bolivian winter, we found the weather on the days when the wind was not blowing, to be very pleasant indeed, with clear blue skies and warm sunshine.

The following data from La Paz should give an indea of the weather throughout the year in the northern part of the Altiplano.

Rainfall and Temperature values for La Paz

(Climatic station at an altitude of 12,200 feet)

| | Rainfall (inches) | Temperature (°F) | (°C) | |
|---|---|---|---|---|
| January | 4.4 w | 52 | 11 | |
| February | 4.4 w | 51 | 10.5 | |
| March | 2.9 | 51 | 10.5 | |
| April | 1.4 | 49 | 9.5 | |
| May | 0.5 | 47 | 8.5 | |
| June | 0.3 d | 44 | 7 | c |
| July | 0.4 | 45 | 7.5 | |
| August | 0.6 | 46 | 8 | |
| September | 1.1 | 48 | 9 | |
| October | 1.7 | 50 | 10 | |
| November | 1.9 | 53 | 12 | h |
| December | 3.6 | 52 | 11 | |

The temperature given here is the mean daily for each month, i.e. each day for a month $\frac{\text{Max} + \text{Min}}{2}$

The values for San Antonio (15,000 ft.) would differ greatly from those of La Paz. The temperature would be a lot lower and the rainfall would be a lot less and confined to the months of December and January. The most significant feature of the weather of San Antonio de Lipez was the extremely cold wind blowing off the Salar de Uyuni. This could well be the reason for the traveller's beliefs of extraordinarily low temperatures.

The following meteorological instruments were taken with us:

1. Baro-thermo-hydrograph

The pressure was far too low to be recorded by this instrument. The thermometer was working well on board the ship, but our efforts to entice it to register correctly in the field were unsuccessful. The humidity was generally below the 10% calibration of the graph, but by adjustment a recording of the humidity variation was obtained.

2. Maximum and Minimum thermometers

These were most successful. They were housed alongside baro-thermo-hydrograph in a box mounted 4 ft. from the ground and in a shade.

3. Earth thermometers, 3", 6" and 9"

These were adequate until some curious villager destroyed them by trying to dig them up.

A graph (Met.2) is shown of the variation of the ground temperature throughout a typical day. There is a noticeable phase difference between the temperatures of the soil at different depths and the air temperature. In the case of the thermometer at a depth of nine inches, the minimum temperature occurs at very nearly the time of the maximum air temperature, i.e. a phase difference of about 12 hours. From this data the thermal conductivity of the soil may be calculated.

4. Anemometer

This was successful. The instrument was of the type where the number of revolutions of the vane were counted for a given time and the wind speed determined from the calibration graph. The instrument was mounted on a "Dexion" pole six feet high on top of the wall of a ruined house.

5. Whirling hygrometer

The wet bulb depression was so great that usually the wet bulb recorded sub-zero degrees. This instrument is unsuitable for this climate.

An interesting result of the low humidity was observed when washing was hung up to dry in the sun. The temperature in the sun would be around 70°F, but the rapid evaporation of the water quickly cooled the wet clothes until they froze.

Whenever possible readings were taken at 08.30 hours, 13.00 hours and 18.00 hours. On certain days readings were taken hourly throughout the day.

General comment about the weather

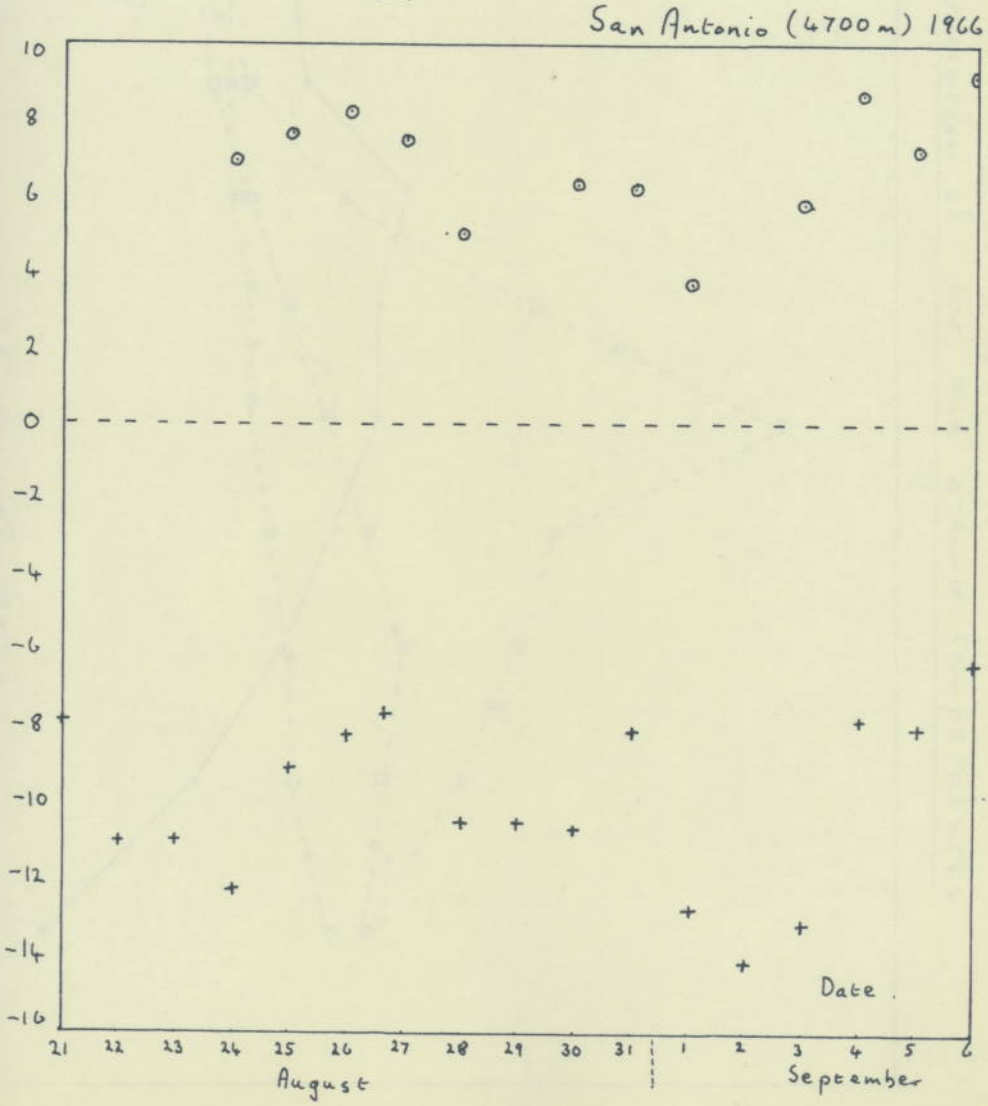
On no occasion did it rain. Generally the skies were clear and the sunshine was very pleasant, but when the wind blew it was too cold to work. The very cold temperatures could be tolerated in the absence of the wind.

Occasionally the skies would be cloudy, in fact one day in San Antonio there was a 100% cloud cover all day.

The weather in San Pablo, 1000 ft. lower, was significantly warmer than at San Antonio, but this was most likely due to normal change in the weather, rather than a large local variation in the climate.

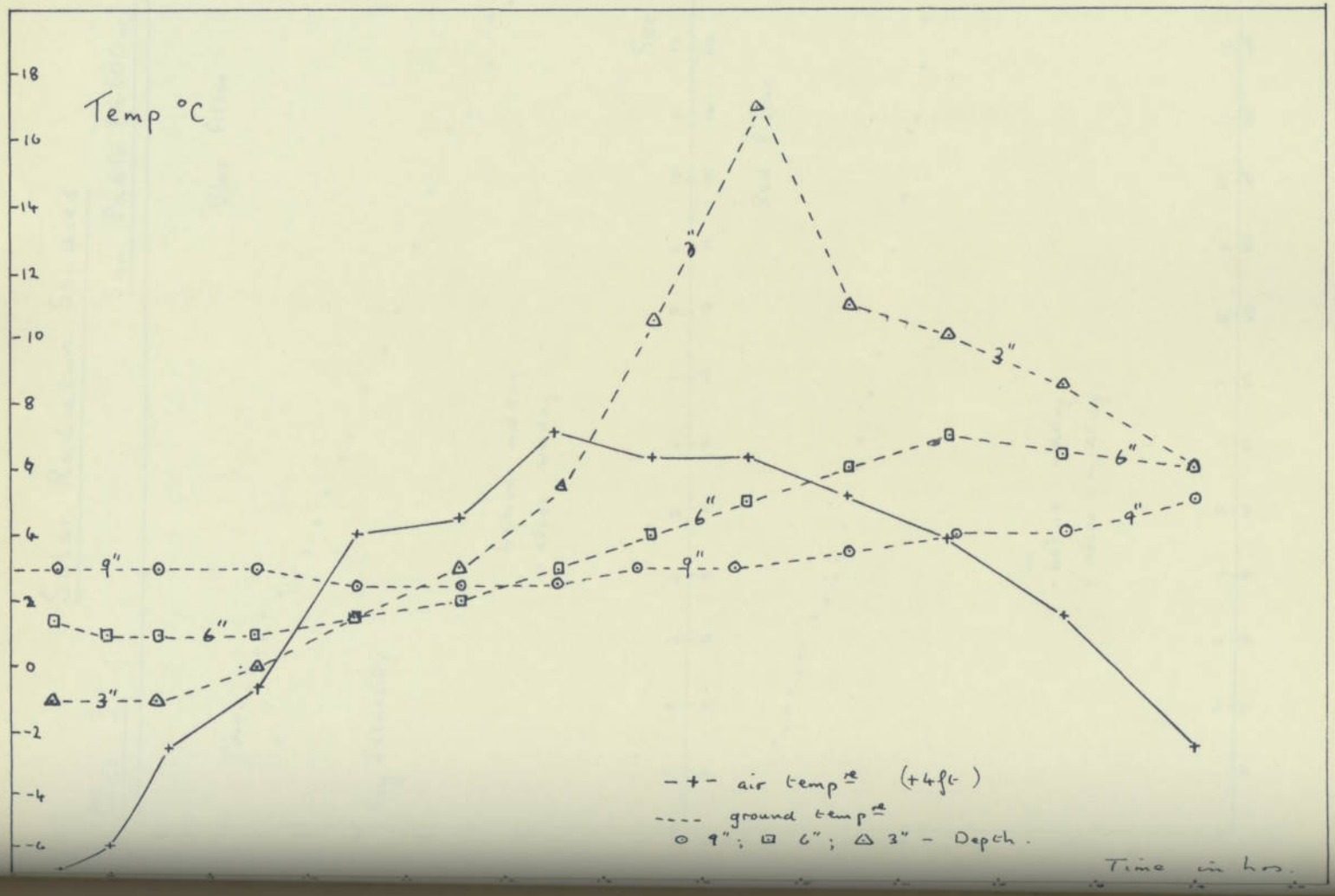
Met. 1. Maximum and Minimum Temperatures

$\overline{Min} = -9.9°C$ (+) $\quad \overline{Max} = +6.9°C$ (⊙) $\quad \overline{Mean} = -1.5°C$



San Antonio 27. 8. '66

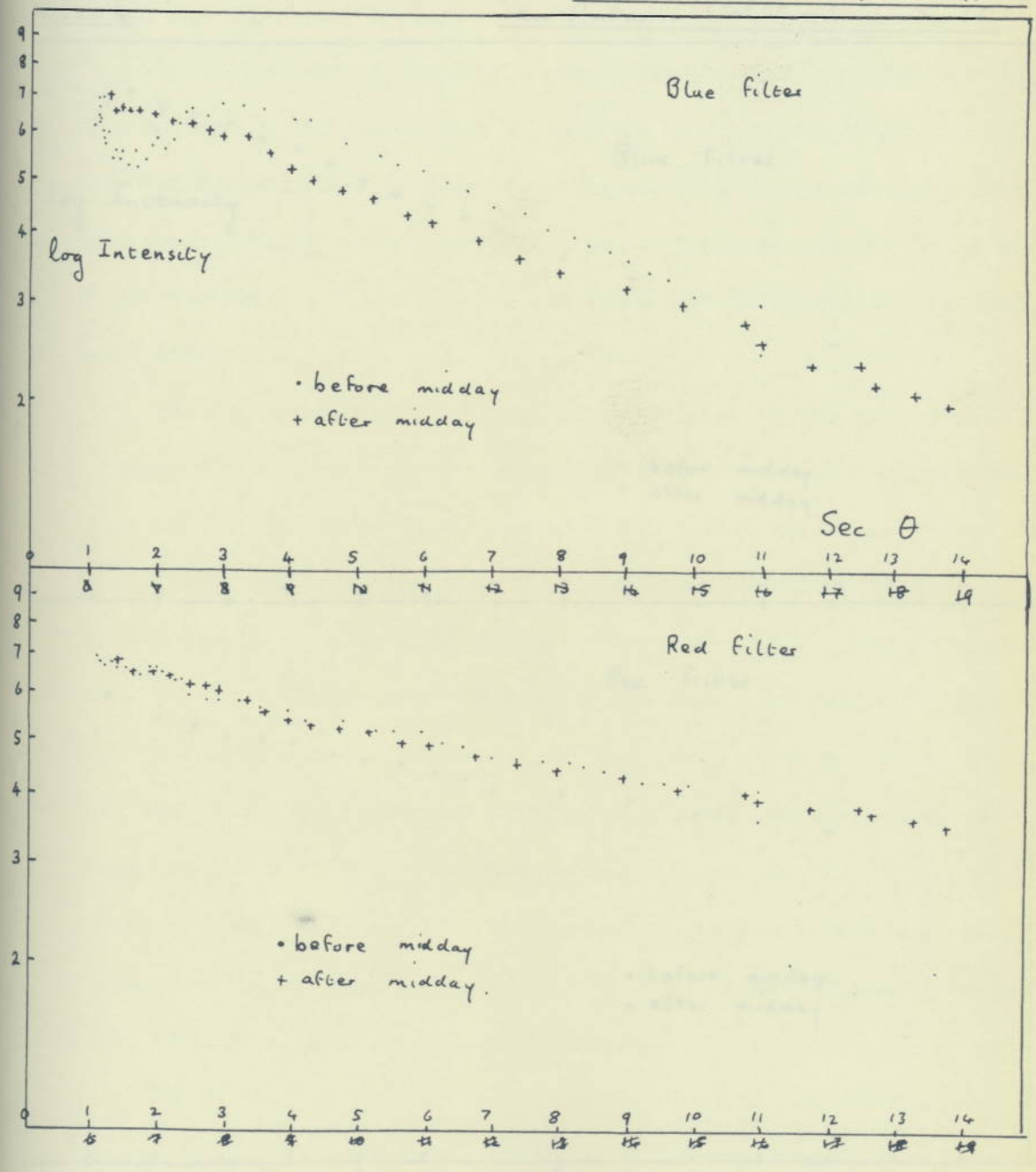
Met. 2. Daytime variation of air and ground temperatures



# Solar Radiation Studies

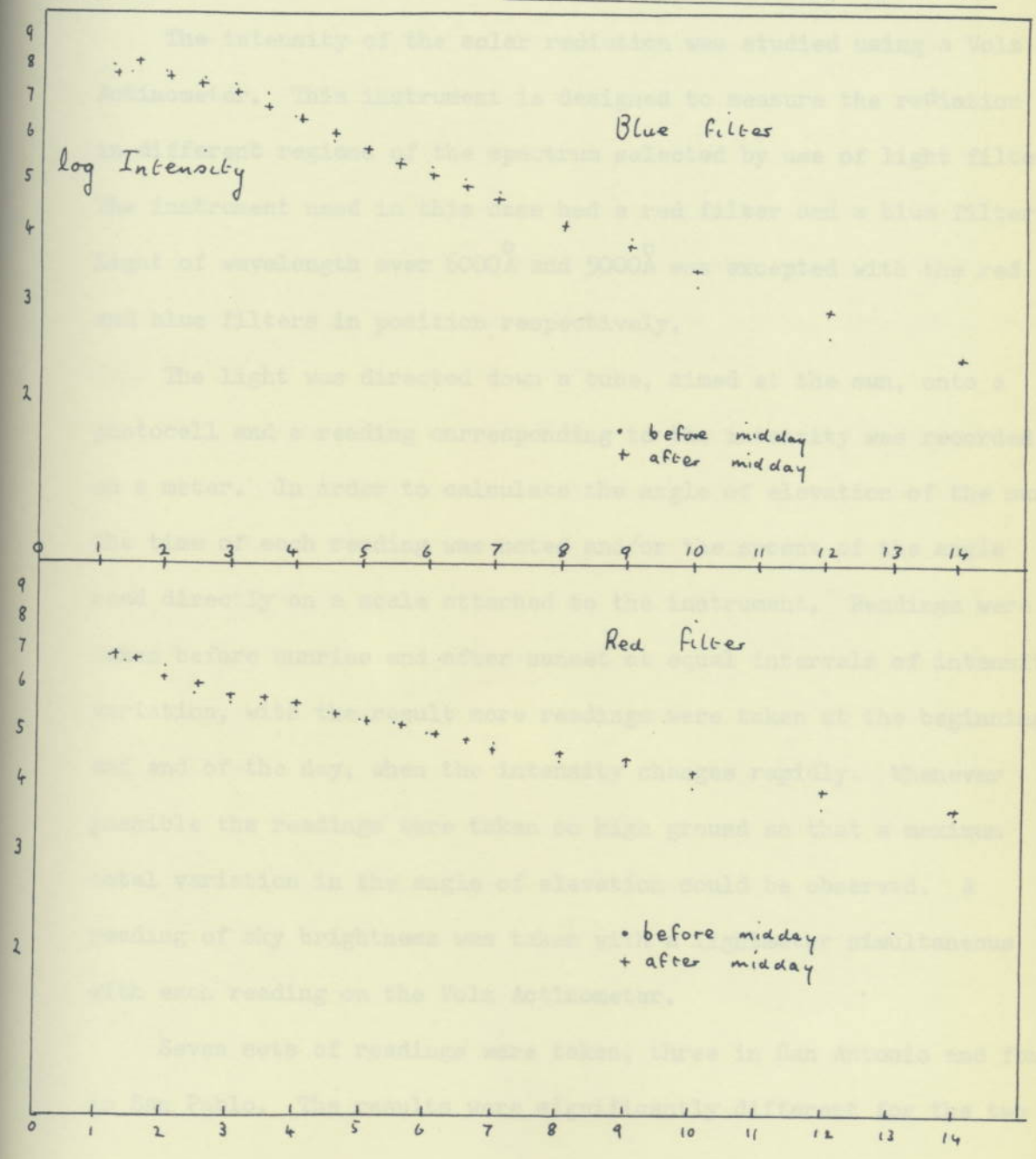
Met. 3

San Pablo (4200m) 15. 9. '66



# Solar Radiation Studies

Met.4. San Antonio (4700 m) 1. 9. '66



Solar Radiation Studies

The altiplano is an excellent laboratory for astronomical and solar and cosmic radiation investigations. The low atmospheric pressure, low humidity and clear skies results in a very low absorption of radiation and near optimum conditions for such observations.

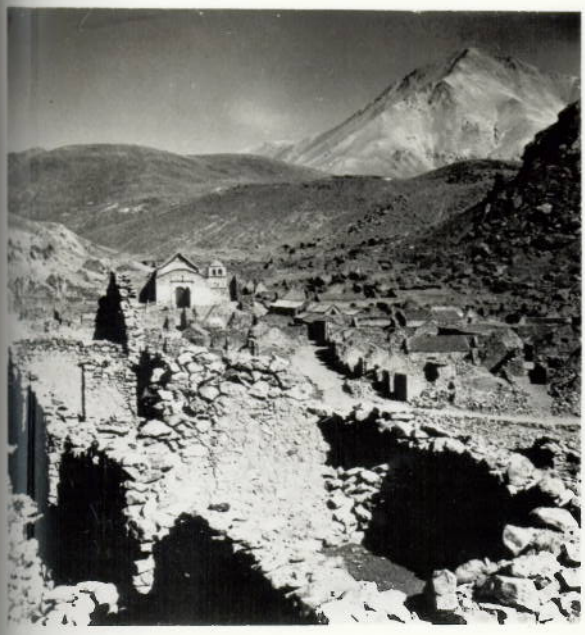
The intensity of the solar radiation was studied using a Volz Actinometer. This instrument is designed to measure the radiation in different regions of the spectrum selected by use of light filters. The instrument used in this case had a red filter and a blue filter. Light of wavelength over 6000Å and 5000Å was excepted with the red and blue filters in position respectively.

The light was directed down a tube, aimed at the sun, onto a photocell and a reading corresponding to the intensity was recorded on a meter. In order to calculate the angle of elevation of the sun, the time of each reading was noted and/or the secant of the angle read directly on a scale attached to the instrument. Readings were taken before sunrise and after sunset at equal intervals of intensity variation, with the result more readings were taken at the beginning and end of the day, when the intensity changes rapidly. Whenever possible the readings were taken on high ground so that a maximum total variation in the angle of elevation could be observed. A reading of sky brightness was taken with a lightmeter simultaneous with each reading on the Volz Actinometer.

Seven sets of readings were taken, three in San Antonio and four in San Pablo. The results were significantly different for the two

locations (see graphs Met.3 and Met.4). With the red filter in position the intensity and its variation with the secant of the angle of elevation ($\theta$) were very similar for the two locations. With the blue filter in position at San Antonio the intensity built up steadily to a maximum at midday and then fell off in a similar steady fashion, but at San Pablo there was a sudden drop in the intensity at about 09.00 hrs. (see $\theta$ about 08.00). The value of the intensity made a partial recovery by midday, but never again reached its morning value for a given value of $\theta$. The measured values of the intensity using the red filter were the same at both locations, but the values using the blue filter were significantly lower in San Pablo than in San Antonio throughout each day.

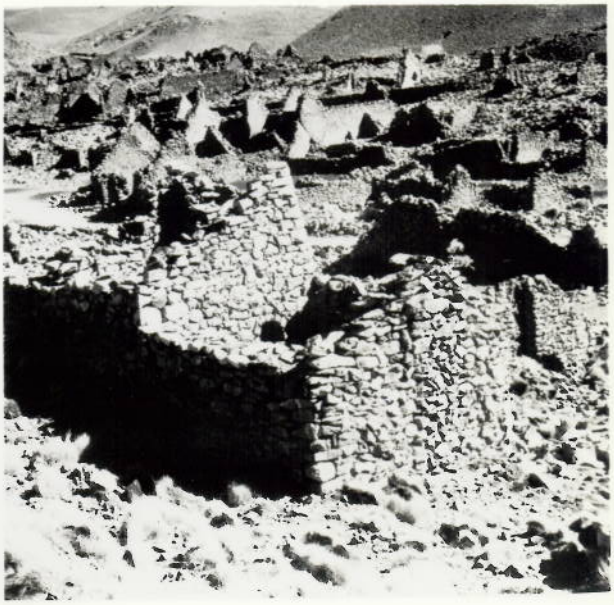
There seemed to be no direct correlation between the humidity at ground level and these anomalous readings. The decrease in intensity of the light was due to either increased atmospheric absorption or light scattering in this region. San Pablo is in a flat, sandy valley and frequent whirlwinds would discharge sand into the atmosphere. The readings in San Antonio were taken on a hill top, high above the stony valley floor. Blue light is more susceptible to scattering than red light and it is most likely the decrease in the blue light intensity was due to scattering by dust particles in the atmosphere.



(1) The ruined village of San Antonio, with the Cathedral in middle distance and Cerro de Lipez (19,500 ft.) in background.

(2) The exterior of the Cathedral, San Antonio. Note the carving around the archway and the bronze bells in the Cathedral. One of these is dated 1720.

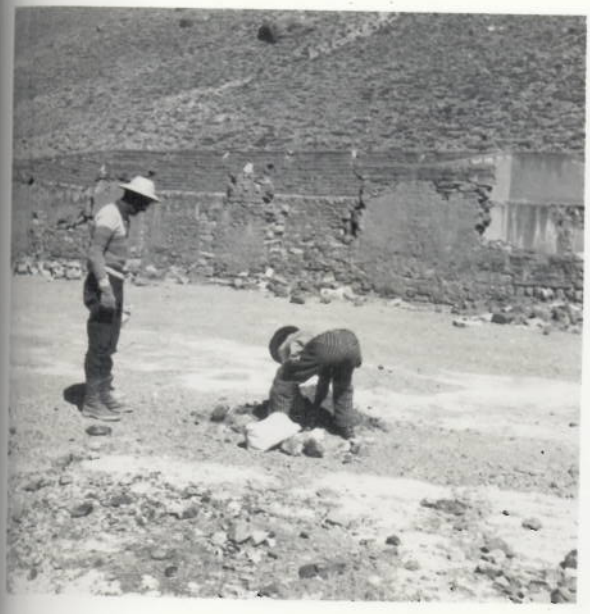
(3) The interior of the Cathedral. The splendour of the altar screen speaks volumes for the former wealth of the area.



(4) A view over the ruined village of San Antoni The old smelter is in the foreground.

Botany - Alan Cope by the side of a very fine "tola" bush.

(6) Meteorology - Cope taking solar radiation measurements. Cerro de Lipez in background.



Sampling - Tony Read supervises an Indian workman digging sampling pits in a spoil-tip. Old mine building in back-ground.

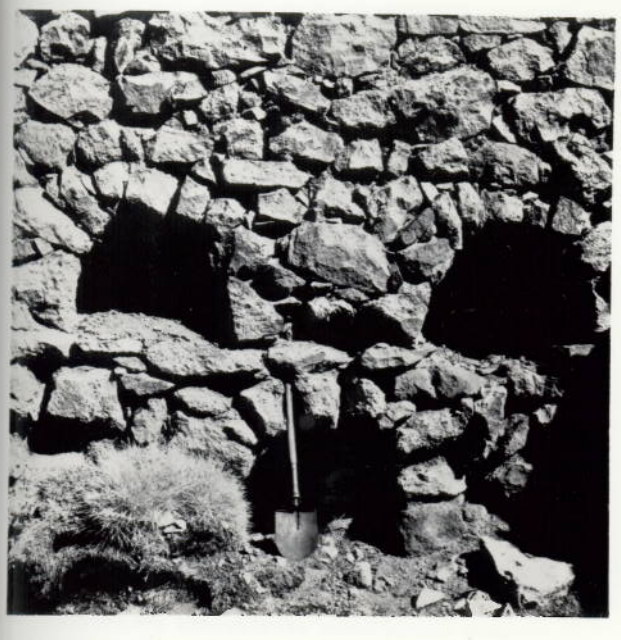
(8) Surveying - Jeff O'Leary surveying near Mesa de Plata Mine.

(13) San Juan Mine (lower left). Note the sub-horizontal stratification in the mountains and the top-heaps in front of the mine.

(14) Ruined buildings, part of the Buena Vista mine complex. The building on the right is an old wheel-house.

(15) The wheel-house in (14). A very deep (several hundred feet) vertical shaft is concealed by the small tola bushes in the middle distance. Note the elegant arched entrance.

(16) The ruined smelter, San Antonio de Lipez. The small shovel in the foreground gives scale.



(17) The "hearths" in the smelter. Out of the picture on the right is the sand-bed used for moulding the molten metal.

(18) "Boulder crusher" for crushing small pieces of ore. Note holes in boulder for wooden poles, used to promote rocking. Still in working order! Maccha Socaron.

(19) The lower slab of a very long crusher, San Antonio. Several boulders such as that in (18) were probably used simultaneously on the slab. Tripod gives scale.

(20) Crushing - 20th Century style! Two Indian women crush bismuth ore at Bolivar Bismuth mine, 25 miles from San Pablo.

(21) Indian miners concentrate cassiterite ore, using a small stream, at Santa Isabel mine, 20 miles from San Pablo.

(22) Indian miners crushing and sorting ore by hand, Bolivar Mine. The vehicle on the left is the expedition's Land Rover, not the Mines

(23) The Land Rover in the field, near San Antonio,

(24) ..... and in trouble, about 10 miles further on. The edge of the road has collapsed under the Geobol vehicle. A few hours' work was required to get out of this minor predicament.

# FOOD

by

Alan Cope

Initially a complete food requirement list was made out, but later this had to be modified to reduce the load on the Land Rover. The amount of space and weight which could be allowed for food was calculated, and then the food packed in order of priority. Another problem was that we did not know how many Bolivian geologists would accompany us and whether they would provide their own food. We decided to be sure on certain essential foods and foods difficult to get in Bolivia, and to rely on being able to buy the rest in La Paz or Uyuni.

We are indebted to help received from previous expedition reports and to advice from Tony Morrison on the availability of food in Bolivia. Much of the food was received free or at a reduced price and we are grateful for the generosity of the food firms. The food was ordered by the Exploration Board Food Committee under the direction of Peter Sellar. Peter Sellar's organisation was so complete, that there was very little for other members of the committee to do, and we are grateful for all the hours of hard work he unselfishly gave to this task.

A list of the food we took with us is given at the end of this chapter, but first here are some general comments about the food.

We took four cases of crispbread and this was ample as we were occasionally able to supplement this with fresh bread. The crispbread proved an excellent means of transferring jams, etc. into the mouth. Honey and marmite were very popular while jams tended to linger.

Porridge provided us with a warm and filling breakfast. The "Ostermilk" was excellent and with practice was used to make good blancmanges and custards. Tea and coffee were the most popular beverages. Tea bags were far more economical and convenient than loose tea. The whisky was a very welcome addition to our evening drinks of hot lemon or milk.

We took tinned meat expecting to supplement it occasionally with fresh meat. In fact we only bought fresh meat on one occasion, when we brought a lamb for about one pound. This made excellent stews for three days. The meat bars were economical as regards weight and space, but did not replace meat as there was nothing to chew. Their most effective role was in the making of a Bolognese Sauce to go with spaghetti. The Oxo's were useful for improving the flavour of the Bolognese Sauce and stews. We bought an 8 lb. bag of dried egg. This was tolerated until Peter discovered fresh eggs could be occasionally purchased from the locals. The tinned fish was popular to eat for lunch-time snacks. We took no cheese as we thought it would deteriorate on the long journey, but we were very grateful for the Argentinian cheeses we were able to buy at Uyuni.

We took 10 lb. of dried potato, which was ample when supplemented with fresh potatoes bought in La Paz and Uyuni. The flavour of the dried potatoes was enhanced by the addition of a little chopped onion.

We bought a tin of cooking oil in Uyuni and this made excellent chips with the fresh potatoes. The spaghetti with a Bolognese Sauce was easy to prepare, tasty and filling. We took all our spaghetti from England, but there was plenty of macaroni-type food available in Uyuni. These wheaten pastes had the advantage over rice in that they cooked quickly in water boiling on the Altiplano. Liquids boil at the temperatures when the vapour pressure of the liquid is equal to the atmospheric pressure. Rice cooks in water at 100°C and consequently we had to cook it in the pressure cooker. This was most safely performed with the rice in some kind of porous bag. The low atmospheric pressure made it necessary to cook most of our meals in our pressure cooker. The dried vegetables improved the flavour of the stews, etc. but the fresh vegetables available at Uyuni were far more popular. We should suggest that future expeditions should definitely include dried onions in their supplies.

Such items as sauce and mustard were only needed in small quantities, but improved the taste of meals tremendously.

The Christmas puddings made meals into feasts, satisfying the role of a tasty filling sweet completely. We cooked pancakes on several occasions with mixed success.

We took too much dried fruit. The dates were very popular, although their effect on one person's digestive system was not.

The sweets - barley sugar and fruit drops - were a great success. Our supply was sufficient to make many friends, particularly with the children, in our generous hand-outs. The mint cake, enerzades and fudge bars also made popular snacks.

We brought a big box of apples in La Paz and a few oranges in Uyuni, which ensured us of a good supply of fresh fruit.

Finally I would like to add for anyone reading this report seeking assistance in preparing an expedition food list, that many of the comments I have made may not be generally applicable as they rely on the personal preferences of four people. However, one thing you will find is that everybody will take an immediate liking to things of which you are running short or you failed to bring.

My grateful thanks to the others for eating the food and for saying they enjoyed it.

| Item | Quantity | Comments |
|---|---|---|
| Ovaltine | 4 tins | Plenty as only two liked it. |
| Tea | 1 lb. | Tea bags bought in Bolivia were preferred. |
| Cocoa | 2 jars | Not popular with us. |
| Coffee | 3 lbs. | The right quantity - popular. |
| Milk, dried | 40 lbs. | Excellent. |
| Porridge | 22 pkts. | Excellent breakfast food. |
| Margarine | 28 lbs. | Sufficient. |
| Salt | 3 lbs. | This could be bought in Uyuni. |
| Crispbread | 48 small packs | Good replacement for bread. |
| Jam | 10 lbs. | Not popular |
| Honey | 3 lbs. | Not enough as very popular. |
| Syrup | 9 lbs. | Too much taken. |
| Peanut butter | 1 lb. | We wanted more. |
| Marmite | 6 x 4 oz. | Excellent, more please. |
| Marmalade | 4 lbs. | Sufficient. |
| Sausage | 10 tins | Very good. |
| Corned beef | 12 tins | Very good. |
| Meat bars | 20 | Good, but not satisfying on their own. |
| Stewed steak | 12 tins | Excellent for stews. |
| Luncheon meat | 2 large tins | Tasty for midday snack. |
| Fish | 30 tins | Excellent for midday meals. |
| Chicken | 12 tins | Very tasty. |
| Vesta Meals | 22 x 2 | They made a welcome change. |
| Dried Egg | 8 lbs. | Not appreciated. |

| Item | Quantity | Comments |
|---|---|---|
| Soup | 112 packets | Excellent and essential. |
| Oxo's | 3 doz. | Excellent, numerous uses. |
| Dried Mixed Vegetables | 12 lbs. | Very good, but too much taken as we were able to buy fresh vegetables at Uyuni. |
| Dried Peas | 4 lbs. | |
| Dried Potato | 10 lbs. | Sufficient with fresh potatoes from Uyuni. |
| Spaghetti | 3 lbs. | Very good, but could have been bought in Bolivia. |
| Tomato Puree | 1 tube | Useful for flavouring. |
| Flour | 5 lbs. | Useful. |
| Custard | 2 tins | Very good. |
| Blancmange | 1 doz. pckts. | Not always successful. |
| Batter Mix | 2 pkts. | Tasty. |
| Treacle Puddings | 10 tins | Very popular. |
| Christmas Puddings | 5 tins | Our favourite dish. |
| Whisky | 24 bottles | No comment; (useful for gifts). |
| Sauce | 3 bottles | Sufficient. |
| Lemonade Crystals | 2 lbs. | Not necessary. |
| Barley Sugar | | Excellent. |
| Fruit Drops | | Excellent. |
| Mint Cake | 5 doz. bars | Ideal for midday snacks. |
| Enerzade | 120 pkts. | Ideal for midday snacks. |
| Fudge Bars | 30 bars. | Excellent concentrated food. |
| Sultanas | 7 lbs. | Good, but too much taken. |
| Raisins | 7 lbs. | Good, but too much taken. |
| Dates | 18 pkts. | Very good, for midday snacks. |

A number of items bought in Bolivia are not mentioned above this gives a fair idea of our diet for the six weeks' stay in the field.

We should like to thank the following for donations of provisions:

A. Abdullah & Sons
Bovril Ltd.
William Carey & Son
Energen Foods Co. Ltd.
Glaxo Laboratories Ltd.
H.P. Sauce Ltd.
H.J. Heinz Co. Ltd.
Hooper Struve & Co. Ltd.
George Mason & Co. Ltd.
Oxo Ltd.
Pasta Foods Ltd.
Quaker Oaks Ltd.
J.H. Senior & Co. Ltd.
C. Shippam Ltd.
Thames Rice Milling Co. Ltd.
Vitamins Ltd.
H.S. Whiteside & Co. Ltd.
Winterbotham, Darby & Co. Ltd.
Boris Bertoya & Co.
British Cocoa Mills (Hull) Ltd.
John Dewar & Co. Ltd.
Farley's Infant Food Ltd.
H.J. Green & Co. Ltd.
Haywards Food Products Ltd.
Horlicks Ltd.
Imperial Chemical Industries Ltd.
McDougalls Ltd.
Park Cake Bakeries Ltd.
Pearce Duff & Co. Ltd.
James Robertson & Sons
Severnside Foods Ltd.
Tate & Lyle Refineries Ltd.
United Biscuits Ltd.
(Wm. Crawford & Sons)
A. Wander Ltd.
Whitworths Holdings Ltd.

Generous price concessions in the purchase of provisions were given by the following:

Batchelors Catering Supplies Ltd.
Carr's of Carlisle Ltd.
W.H. Cullen
Kavli Ltd.
Oxo Ltd.
Templeton Patents Ltd.
Cadbury-Fry
J. & J. Colman Ltd.
C. & T. Harris (Calne) Ltd.
Thomas Mitchelhill Ltd.
George Romney Ltd.
Van den Berghs Ltd.

# EQUIPMENT

by

Peter Francis

In this section, it is not proposed to catalogue the one thousand and one items that any expedition takes into the field, but rather to concentrate on three topics: equipment that proved to be particularly useful, equipment we had but found unnecessary, and finally, equipment we did not have but would have found very useful.

## Particularly useful items

The two double-burner "Optimus" petrol stoves (catalogue No.22B) we used turned out to be extremely good, giving no trouble at all during many hours of use. Having four burners available made cooking very easy, and we made full use of them. Optimus expressed concern as to how these particular stoves would work at our altitude - they can rest assured of their excellent performance.

Prestige Ltd. donated to the expedition a pressure cooker. This saw a great deal of use, and was particularly valuable for the rapid cooking of stews and other concoctions which would otherwise have taken a great deal of cooking at this altitude.

The other particularly useful items were the sleeping bags by Blacks. These, inner and outer "Icelandics" ensured warm nights throughout the field work, even in the very low temperatures encountered. The outer bags were also useful in their own right, when sleeping out in the desert en route, and occasionally in hotels where the bed linen was on the dubious side.

Unnecessary items

The major item here was the 30-ft. electron ladder. As it happened, most of the mines could be entered by horizontal or inclined adits, but when equipping the expedition, we had no knowledge of this, and had to be prepared for vertical entrance shafts. The same applies to the Karabiners and ropes we carried - they could have been important, but as it happened, were not.

An over-estimate on the part of the Equipment Officer lead to rather too much toilet paper being carried. In this case, better too much than too little!

Items we should have had

The most important thing here was a small pump of some sort for getting water from shallow streams into jerry-cans. This was mentioned briefly in England, but the idea somehow died, and the result was that the jerry-cans had to be filled by hand-using a billy-can as a bailer - from the just-melting streams. This freezing unpleasant job somehow devolved on Tony Read, who did it admirably, and without complaint nearly all the time we were at San Antonio.

A "Tilley" lamp would have been useful. Ismael Montes d'Oca left us the "Geobol" lamp when he returned, but after one or two minor incidents, this lamp exploded in vast sheets of flame and would surely have burned the roof off the hut, had we not been at 15,000 ft. For the rest of the time in the field, we had to rely on a travelling light, run from the spare battery from the Land Rover.

Somehow only two tins of dubbin got into the field. This was not enough.

Certain members of the party acquired an obsession for looking at themselves in a looking-glass. Future expeditions are recommended to carry a full-length mirror to satisfy this desire.

We are grateful for gifts of equipment from the following companies:

Exide Batteries Ltd.
Ronson Products Ltd.
Smith's Industries Ltd.
Wilkinson Sword Ltd.
The Metal Box Company Ltd.
The Gillette Safety Razor Company Ltd.
Prestige Company Ltd.
British Industrial Plastics Ltd
Premier Cap Lamp Co. Ltd.
Martin and Company, La Paz
The Bata Shoe Company Ltd.
British Visqueen Ltd.

and for generous price concessions from:

Blacks of Greenock Ltd.
Polaroid (UK) Ltd.
Michelin Tyre Company Ltd.
Milletts (Western) Ltd.
Ever Ready Battery Co. Ltd.
P.B. Cow Ltd.
Optimus Ltd.

# VEHICLE REPORT

by

Tony Read

## Selection of vehicle

In order to visit this remote part of Bolivia it was necessary to obtain some means of transport for us and our equipment.

Initially we considered obtaining three solo motor-cycles, which would be very suitable for the terrain. We planned to hire a lorry in Uyuni to take our food, equipment and petrol to a central point in San Lipez, which we would use as our base. This course was rejected for the following reasons:

(1) Ignorance of the availability of lorries in Uyuni;

(2) Difficulty in transporting sick or injured members;

(3) Discomfort of motor-cycling in the very cold climate.

In retrospect, although we could have reached some of the more remote areas and possibly more mines with the motor-cycles, travel on the badly pot-holed roads in the remainder of Bolivia would have been slow and hazardous.

After deciding that a four-wheel drive vehicle was necessary for our purposes, the possibility of hiring a vehicle in Peru and Bolivia was investigated. The British Embassy in La Paz, the U.N. Geological Survey and various individuals were approached, but no vehicles could be obtained.

We were therefore resigned to purchasing a vehicle in England, shipping it out to South America and, if possible, selling it there at the termination of the expedition. It was decided that the vehicle most suited to our purposes would be a petrol-driven long-wheel base Land Rover, preferably series IIA; the larger engine fitted in this model would be useful in view of the high altitude conditions and steep gradients it was likely to encounter. A large number of vehicles were inspected.

Finally a 1961 L.W.B. 12-seater petrol driven Land Rover was purchased for £550 from Ickenham Motors, Ickenham, Middlesex.

An A.A. report on the vehicle was obtained before it was purchased. The cost involved was £5 10s. Od. The report was generally favourable, but was very non-committal in some respects. It could be relied upon to find out major present faults, but would not be a good indicator of faults likely to develop in 6,000 miles of driving on rough roads. The vehicle had only been used for private use and in view of its good overall appearance and acceptable mileage (35,000) was thought to be basically sound.

The vehicle was subsequently checked over by an instructor at the Rover Co. School at Solihull and an inspector at the Rover Repair Depot in Fulham, and was found to need only a minor adjustment to steering mechanism.

Modifications carried out on vehicle

(1) Heavy duty rear springs and shock absorbers fitted.

(2) Michelin XY tyres fitted all round.

(3) Exide 12-volt heavy-duty battery fitted (capable of giving high current for cold starting).

(4) Home-made roof-rack constructed.

(5) Water can racks constructed.

(6) Winch drums fitted to front wheels.

Modifications necessary on journey

It was necessary to adjust the timing and carburettor jets to cope with the changing altitude and the low octane rating of the petrol. The recommended jets are as follows:

| Altitude | Main Jet No. | Pilot Jet No. |
|---|---|---|
| 5 - 7,000 ft. | 120 ) | as sea level |
| 7 - 9,000 ft. | 117.5 ) | |
| 9 - 12,000 ft. | 115 | 45 |
| 12 - 15,000 ft. | 112.5 | 45 |

Preparations for possible breakdowns

It was decided that we would take all reasonable preparations to cope with most possible breakdowns. But if the vehicle broke down in the field (up to 120 miles from a possible tow) and was not mendable with our resources, we would be prepared to walk out with the hired

llamas to get a towing vehicle. We made the following preparations to cope with most possible eventualities.

Land Rover Service School

The Rover Motor Co. operate periodically a three-day owner-driver maintenance course, suitable for people taking their vehicles to remote areas. Tony Read went on such a course in March 1966, and found it most helpful. The instructor gave out a list of recommended tools and spare parts, which formed the bulk of the items taken.

Further details of this case can be obtained from Mr. S.R. Johnson, Chief Instructor Service School, Technical Service Department, Rover Motor Co., Solihull, Warwickshire.

Spare Parts

The spare parts considered necessary for most likely breakdowns were purchased. It is possible to obtain spares for Land Rover Series I at around 50% of usual price from 'Autotools' of Beresford Road, Solihull. By a careful study of the parts catalogues it was possible to find which parts were common to Series I and IIA, and obtain these at a good discount. The remainder were purchased at the full retail price.

The possibility of obtaining spares on a use-or-return basis was investigated, but neither Rovers nor the garage approached would co-operate. The parts taken are listed in Table 1.

## Table 1

### Spares for Land Rover Series IIA

The following spares were taken on the expedition:

Engine parts

1 Overhaul gasket set

2 Oil filter elements

2 Fan belts

4 Champion N.8 sparking plugs

4 Valve collets

2 Exhaust valves

1 Inlet valve

2 Cylinder head bolts

1 pair Big end shells

1 pair Rear main bearing shells

1 Water pump

1 Overhaul kit for petrol pump

1 Overhaul kit for Carburettor

2 Water hoses

Electrical parts

1 Distributor cap

1 Condenser for distributor

1 set Contact points

1 Rotor arm

1 Ignition coil

1 length HT cable

Table 1 (cont)

Electrical parts (cont)

1 length of lighting cable

1 set of Starter motor parts

Fuses

Miscellaneous light bulbs

Transmission parts

1 Long rear half-shaft

1 Clutch plate

1 Oil seal for swivel housing (front axle)

1 Oil seal for front hub (brake)

2 Rear axle check straps

Brake parts

1 qt. Brake fluid

1 Front flexible hose (chassis to wheel unit)

1 Rear flexible hose ( " " " " )

1 Wheel cylinder overhaul kit (rear)

1 " " " " (front)

1 set Brake drum screws

Suspension and steering

1 Main leaf for front spring

1 " " " rear " *

2 Rubber covers for steering ball joint

Table 1 (cont)

Miscellaneous items

A large comprehensive selection of A.F. and B.S.F. nuts and bolts, numerous washers

1 tin Castrolgrease

1 roll Insulating tape

1 container Holt's Dampstart

1 Puncture outfit

1 tube Sealing compound

1 tin Grinding paste

1 tin Radweld

1 tin Penetrating oil

2 Hose clips

Customs and shipping formalities

It was necessary to obtain a Board of Trade export licence to remove the vehicle from England. A carnet was purchased from the AA, to satisfy the temporary import regulations of the countries to be visited. It was necessary to obtain a guarantee of £550 for the AA which would be forfeited if the vehicle was not re-exported from South America before the expiration of one year. The Exploration Board arranged such a guarantee with the College Bankers.

It took two days to clear the Custom's formalities in Tahara, N. Peru. It would have taken far longer had it not been for the mediation of the Lobitos agent in Tahara, Senor Carera. The value of such an ally in a South American port cannot be underestimated. The Peruvian Customs required an additional guarantee from Lobitos for the transit of the vehicle and equipment through Peru. They did not give us a covering document, which could be cleared on leaving Peru; this omission caused us much trouble later. The Peruvian AA completed all formalities for the return shipment to London.

Insurance

The vehicle was insured for three months with the Felix Pervana (Cosilla 1356, Lima, Peru) at a cost of £31 (42% of the annual premium). The agent in England was Insurhire Ltd, of 31 Cherry Orchard Road, Croydon, Surrey.

## Tools

A comprehensive tool-kit was purchased. The bulk was purchased from Farmer Bros. of Fulham Roads, S.W.10, who gave a very favourable discount. Further tools were puchased from Pride and Clarke of Brixton, who market a range of good cheap imported tools.

The tool kit is listed in Table 2. Those asterisked were needed, but not taken.

### Table 2

### Tools

1 set A.F. open spanners 7/16" - 7/8" (no overlap)

1 set A.F. ring spanners 6/16" - 7/8" (no overlap)

1 set A.F. box spanners 7/16" - 7/8" (no overlap)*

1 set Whitworth B.S.F. open spanners 1/8"W - 1/2"W (no overlap)

1 set Whitworth B.S.F. ring spanners 1/8"W - 1/2"W (no overlap)

1 Wrench

1 3/4" A.F. socket

1 5" extension bar

1 Tommy bar

1 Plug spanner*

1 Warner 315 grease gun

1 pr. Rubber-handled electrician's pliers

1 8" adjustable spanner

1 Mole wrench

1 Stanley 10" screwdriver

1 Stanley 3" screwdriver

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Table 2 (cont)

| | |
|---|---|
| 1 | Small electrician's screwdriver |
| 1 | No.1 Philips screwdriver |
| 1 | No.2 Philips screwdriver |
| 1 | Hacksaw 40 P.G. + blades |
| 1 | Small hacksaw + blades |
| 1 | ½lb. ball-pane hammer |
| 1 | Thor copper/hide hammer |
| 1 | Pin punch |
| 1 | 1/4" pin punch |
| 1 | 10" Cold Chisel 1/2" wide |
| 1 | Flat file |
| 1 | Round file |
| 3 | Tyre levers |
| 1 | Axle jack |
| 2 | Bumper jacks (for soft ground) |
| 1 | Foot pump |
| 2 sets | Feeler gauge |
| 1 | Drill and bits |

Attempted re-sale of vehicle in Bolivia

Land Rovers are at a high premium in Bolivia, being regarded as a status symbol. Hence there was no shortage of potential purchasers for our vehicle. However, the procedure to validly import the vehicle is so complex that we had to abandon the procedure. There are separate charges for importation, registration, transfer to new owner, and to the local council as well as number plates to be purchased. If we had to repeat the procedure we would approach a certified custom's agent who, for his fee, would get everything done. Since every form has to be signed by the Head of the Customs House, La Paz, and some even by the Minister of Economics, progress can be very slow.

Performance of vehicle on the expedition

The vehicle performed very well over the 6,500 miles covered in South America with only one significant breakdown.

Details of the roads covered, fuel consumption, cost per mile, etc. are shown in Table 3. The total expenditure on petrol and oil was £47, which is equal to an average 1.7d/mile.

The power developed by the engine was always adequate to carry us and our load up the steep inclines encountered even at altitudes in excess of 15,000 ft. The four-wheel drive and good tyres ensured that we did not have to dig the vehicles out at any stage. One of the Chevrolets, which accompanied us for part of the trip was stuck on three occasions.

Care was taken not to overload the Land Rover beyond the recommended maximum for rough roads (1,400 lbs). Despite this care, one of the small leaves on the rear offside spring broke off, probably on the road from Uyuni to Potosi. The 'road' which was the worst we encountered, traversing bare rock for much of the way. No further deterioration in the condition of this spring was observed during the subsequent 2,000 miles of motoring to Lima.

The one major breakdown, which delayed us was the disintegration of the starter motor drive mechanism, while we were in San Antonio de Lipez. A split pin, which held the locking-nut in position had fallen out and subsequently the various parts of the drive-mechanism were distributed between the road and the clutch housing. By removing the carburettor, manifolds etc. it was possible to remove the parts from the clutch housing and on replacing the starter motor etc. the vehicle was again driveable. We did not have the spare parts to perform a permanent repair. The vehicle had to be bump-started or cranked. Surprisingly cranking at 15,000 ft. was an easier operation than at sea level due to the lower atmospheric pressure. A telegram went from Pan Pablo de Lipez to Martin y Cia, the Land Rover agents in La Paz, requesting they send the necessary parts to Uyuni. They were able to send some of the parts; the remaining part was designed b and its manufacture supervised by Senor Armaza, a senior engineer at the Railway Workshop in Uyuni. We were able to carry out the repairs in Senor Huanca's garage in Uyuni. This gentleman took the day off work to assist us with the repairs.

In retrospect

The plan for a future expedition would be to buy or hire a four-wheel drive vehicle in Lima, which would transport the personnel and equipment by road to Bolivia. The advantage of hiring a vehicle in Lima as against La Paz is that it would eliminate sending unaccompanied luggage to La Paz. It takes nineteen signatures to clear one suitcase from the Customs House. The formalities at the road border are minimal.

Table 3 - Performance of vehicle on South American Roads

| Starting point | Destination | Mileage | Time taken (hrs) | Miles/ gallon | Cost/mile (pence) | Quality of road |
|---|---|---|---|---|---|---|
| Talara | 20 miles north of Chicago | 230 | 6 | 13.9 | 1.48 | good - graded |
| 20 miles north of Chicago | 10 miles north of Chancay | 367 | 10 | 13.9 | 0.99 | good - graded |
| 10 miles north of Chancay | Lima | 120 | 3 | 13.0 | 1.20 | good - graded |
| Lima | Palpa | 260 | 7 | 13.8 | 1.54 | tarmac |
| Palpa | Arequipa | 437 | 11 | 9.8 | 1.27 | tarmac |
| Arequipa | Puno | 187 | 8 | 13.8 | 1.13 | very mountainous, rises to 15,500 ft. but reasonable gradients |
| Puno | Deseguadero Bolivia/Peru border | 94 | 4¼ | | | moderate, many customs check points |
| Deseguadero | La Paz | 77 | 3½ | | | moderate, unmarked level crossings |
| La Paz | Oruro | 150 | 4½ | 12.8 | 2.57 | bad, improving |
| Oruro | Challapata | 70 | 3 | | | bad, with corrugations |



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Table 3 continued

| Starting point | Destination | Mileage | Time taken (hrs) | Miles/ gallon | Cost/mile (pence) | Quality of road |
|---|---|---|---|---|---|---|
| Challapata | Rio Mulatos | 55 | $3\frac{1}{2}$ ) | ) | ) | bad |
| Rio Mulatos | Uyuni | 50 | $3\frac{1}{2}$ ) | ) No data, petrol | ) | very bad |
| Uyuni | San Antonio | 110 | $4\frac{1}{4}$-7 ) | ) filled from | ) | moderate, but bad at fords |
| San Pablo | Uyuni | 112 | 5 ) | ) 40 gallon cans | ) | moderate, but bad at fords |
| Uyuni | Potosi | 142 | $8\frac{1}{2}$ | 15.1 | 1.82 | appalling |
| Potosi | Sucre | 105 | 5 | 9.6 | 2.5 | moderate - good |
| Sucre | Cochabamba | 226 | $9\frac{1}{4}$ | 8.5 | 2.6 | moderate, last 100 miles tarmac |
| Cochabamba | Santa Cruz | 309 | 9 | 14.0 | 1.71 | good - tarmac |
| Santa Cruz | Cochabamba | 309 | $8\frac{3}{4}$ | 12.3 | 1.81 | good - tarmac |
| Cochabamba | La Paz | 239 | $8\frac{1}{2}$ | 13.8 | 1.78 | moderate to bad |
| La Paz | Corroicco | 59 | 3 | | | good |
| La Paz | Puno | 167 | $6\frac{1}{2}$ | 13.4 | 1.42 | moderate |
| Puno | Arequipa | 180 | $6\frac{1}{2}$ | 16.2 | 1.0 | moderate |
| Arequipa | Camaña | 106 | $2\frac{3}{4}$ | ) | ) | tarmac |
| Camaña | Lima | 550 | 14 | ) | ) 0.95 ) | |

# MEDICAL REPORT

by

Peter Francis

## General

This section is fairly short, because happily there were no serious accidents or illnesses at all during the expedition, though there were a few incidents of a relatively trivial nature which were well within the scope of our first aid.

We were very fortunate in obtaining the services of Dr. J.H. Briggs, of Charing Cross Hospital as our Medical Adviser. Dr. Briggs not only attended to the very comprehensive medical supplies that we took into the field, but also arranged for one member of the party to visit Charing Cross Hospital Casualty Department, in order to get some first-hand practical experience of first aid.

## Innoculations and Precautions

All members of the party were immunized against smallpox, yellow fever, typhoid and tetanus for their protection in the populous, tropical countries en route - in the field there was actually little danger from disease, due to the very cold, dry, almost sterile nature of the area, which was also virtually uninhabited.

In spite of this, we did try to boil all drinking water in the field, as an added precautionary measure, and this was found to be particularly necessary when the expedition was based at San Pablo, where the stream, although usually frozen, was found to contain

mosquito larvae and other bugs - remarkably hardy bugs at that. Naturally, in the tropical parts of the journey, we drank no untreated water, and tried to get refreshment only from bottled soft drinks (the inevitable coca-cola!) and beer (variable, but generally a quite good lager type).

Entero-vioform was taken sposmodically by all members of the party at one time or another, to combat the effects of diarrhoea, and fortunately we never had a really bad case of this predictable complaint. This, in spite of the calculated risks we took in eating dubious dishes such as salads and ice-cream. Two factions developed in the party, one favouring an "eat, drink, and be merry, for tomorrow we die" attitude, and the other much more cautious.

Acclimatization

During the expedition, the members experienced the contrast from an idle life of luxury at sea level (in the El Lobo) to really quite strenuous work at about 16,000 ft. a few weeks later. This gave us a very good first-hand experience of altitude acclimatization, and we were all rather surprised at how easily we acclimatized, in spite of the initial rather unpleasant effectswwe all felt when setting up base camp at 15,200 ft. in San Antonio.

The bus-and-train party reached La Paz with no altitude sickness at all, but the Land Rover party, in coming up from Camana to Puno did feel some ill effects on the Arequipa-Puno leg, where the road reaches about 15,500 ft. One was rather sick, and the other developed a bad headache. This was in spite of a day's acclimatization at about 8,000 ft. in Arequipa.

In La Paz itself, the only noticeable effect was a slight breathlessness when walking uphill, but nothing worse, and it was not until we reached San Antonio that really marked symptoms were felt.

On the first day at this altitude (15,400 ft) no ill effects were noticed and everybody was working fairly hard, perhaps too hard, at setting up camp and getting organised. Waking up the following morning was a sad contrast, with all members feeling pretty much the worse for wear and complaining of symptoms of nausea, headache and general lassitude.

One member was really quite ill, spending a couple of days in bed with a temperature reaching 101.6°F and complaining in particular of "queasiness". Bed-rest and dosing with codeine seemed to be about the only possible treatment, and proved to be quite adequate. With this exception, the altitude sickness was by no means alarming and meant only that we spent the first few days in light work, mainly in reconnaissance trips in the vehicles. After a few weeks in San Antonio, the party had become sufficiently fit and acclimatized for two members to climb to 19,750 ft. on the "Cesso de Lipez" without too much distress, a measure of their degree of acclimatization.

Pulse rate

Directly related to the altitude was another condition that we all experienced. This was an extremely painful drying out and chapping of the hands and fingers, prdocued by the excessively dry, cold air and the frequent very strong, bitter winds. This produced cracks across the knuckles, on the joints of fingers and thumbs, and sometimes on the balls of the fingers. The condition was aggravated by the

necessity of manipulating surveying instruments in the very cold winds, and any movement of the fingers tended to open up the cracks afresh, causing them to bleed, sometimes profusely.

Naturally, members of the party were affected to differing extents, and the meteorologist certainly came off much the worse, since his job entailed spending long periods on top of a very exposed hill, at dawn and at sunset, and having to make fine adjustments to his instrument every few minutes.

Treatment consisted of wearing gloves whenever possible, and only removing them when strictly necessary, and rubbing in large quantities of handcream before going out for the day. Noses and ears were occasion occasionally painfully cold, but not to anything like the same extent as hands.

Before concluding this section, it is interesting to note that on the return journey, two members felt very sick at Cochabamba (6,000 ft) - nausea and vomiting - and on the journey down to Santa Cruz, 1,400 ft. Whether this was inverted mountain sickness, due to being fully acclimatized to higher altitudes or to something completely different such as food poisoning, is a matter for debate.

Other incidents

There is really little else to report, apart perhaps from a medical "first" - we are fairly sure that there have been few, if any, cases of people suffering from the effects of cactus spines in the mouth. This unfortunate incident occurred to the botanist, when preparing his material for Kew, but he is not really sure how so many

spines got so far into his mouth. Removing them turned out to be quite tricky, requiring the use of forceps and a torch, for the spines were very small and difficult to see. The patient, however, endured the operation, and the accompanying ribaldry very well, and nearly all the spines were removed. Those that were not are either still there, or have been digested.

Medical Supplies

The following is a complete list of the medical supplies taken into the field. Their use, if any, is also indicated; items not used were brought back to England.

| Item | Use |
|---|---|
| 1 roll cotton wool | Given away |
| 8 tubes Cool-tan | 4 used en route |
| 1 packet absorbent lint | |
| 1 cylinder Kaolin Powder | |
| 1 bottle Calodril lotion | Lost |
| 1 cylinder Dequadin lozenges | Some used |
| 1 cylinder DDT Powder | |
| 1 bottle Savlon Antiseptic | Given away |
| 2 tubes Savlon cream | 1 used |
| 3 elastic adhesive bandages | 1 used |
| 4 packets Elastoplast | 2 given away |
| 7 crepe bandages | 1 used |
| 2 rolls adhesive plaster | 1 used |
| 1 bottle Paladrine tablets | Some used |
| 1 cylinder foot powder | |
| 2 cylinders Entero Vioform | Mostly used |
| 1 bottle Codeine tablets | Used, some, lost rest |
| 2 tins Mycil dusting powder | Given away |
| 6 sq.yds. gauzes | Given away |
| 1 bottle Avomine | 1 or 2 tables used |
| 3 bottles Succinyl Sulphathinzol | |

| Item | Use |
|---|---|
| 1 bottle Hialozone tablets | Some used |
| 1 packet Droxalin | |
| 6 tins Nivea Creme | Used |
| 1 tube Anthisan | Used |
| 1 packet safety pins | |
| 2 triangular bandages | |
| 1 methylated spirit spray | |
| 4 Plaster of Paris splints | |
| 1 paraffin gauze dressing | |
| 1 tube Sulphacetamide eye ointment | |
| 2 boxes needle and thread | |
| 4 boxes Penbritin | |
| Water for Penbritin injection | |
| 1 bottle Pethadin HCl tablets | |
| Pethadin for injection | |
| 1 bottle salt tablets | Broken and spilt |
| 1 bottle eye drops | Evaporated |
| 1 bottle Ampcillin capsules | |
| 1 bottle Oil of Cloves | |
| 1 bottle Occusol | |
| 1 eye bath | |
| 1 bottle Lornotil tablets | |
| 2 bottles Lignocaine HCl | |
| 1 bottle Piriton tablets antihystamine | |

| Item | Use |
|---|---|
| 2 eye masks | |
| 1 bottle Senokot | |
| 2 tubes Skeetofax | 1 used |
| 1 box Tetracycline | |

N.B. Copies of "A Traveller's Guide to Health" by
and a "Health Appreciation of Bolivia" prepared by A.G. Harwood were also carried, and proved to be extremely useful.

The items labelled as "given away" were given to the schoolmaster in San Pablo for the use of his wife and family, and of other people in the village. Nothing likely to be harmful if mis-used was given, so there was no chance of accidents.

# FINANCIAL REPORT

by

Peter Francis and Alan Cope

It costs a lot of money to transport four people, a vehicle, and several hundredweight of essential equipment almost halfway round the world. Initially we had no idea where all this money was going to come from, but fortunately many large mining companies and their associates responded generously to our appeal for support. In addition, the offer of free sea passages by the Lobitos Oil Company eliminated a major portion of the anticipated expense, and made the project financially feasible.

However, it is fashionable these days for the cost of any project to escalate considerably as time goes on, and this expedition was no exception. There were two main reasons for this, the most important being the British Seamen's Strike, which forced us to come back by air contrary to our original plan. Secondly, it had been intended to sell the Land Rover in Bolivia, but this turned out to be almost impossible so we were forced to ship it back to England again, at further expense. Also, the price of second-hand vehicles had dropped considerably in London, so a further loss was incurred on the sale of the Land Rover.

We would like to conclude this brief report by recording our thanks to Mr. Stera of the College Accounts Office for his sterling work in the unenviable job of sorting out the Expedition accounts.

## Balance Sheet

| Received | £ | s. |
|---|---|---|
| William Harvey & Co. Ltd. | 60 | |
| Capper Pass & Son Ltd. | 400 | |
| Holman Bros. Ltd. | 50 | |
| Morgan Guarantee Trust | 105 | |
| Rio Tinto Services Ltd. | 50 | |
| International Nickel Ltd. | 25 | |
| Consolidated Gold Fields | 50 | |
| Hoover Trust Fund | 50 | |
| W.J. Yapp Charitable Trust | 25 | |
| Mackay & Schellmann Ltd. | 10 | 10 |
| John Dewar & Sons | 50 | |
| Roan Selection Trust | 100 | |
| Gilchrist Educational Trust | 50 | |
| Anglo American Corporation | 100 | |
| South Crofty Ltd | 25 | |
| Article in "The Times" | 52 | 10 |
| Imperial College Exploration Board | 250 | |
| Private donation | 10 | 10 |
| Personal contributions | 240 | |
| | £1,703 | 10 |

| Spent | £ | s. |
|---|---|---|
| Travel, Lima - London | 555 | |
| Internal travel | 70 | |
| Land Rover depreciation | 130 | |
| Land Rover spares and tools | 150 | |
| Land Rover and equipment freight | 203 | |
| Equipment | 130 | |
| Food | 158 | |
| Photographic materials | 36 | |
| Medical supplies | 20 | |
| Brochure | 40 | |
| Postage | 30 | |
| Report and literature survey | 70 | |
| Miscellaneous | 135 | |
| Deficit | 24 | 10 |
| | £1,703 | 10 |

N.B. This deficit in our accounts is due to the unexpected expenses we had to meet, such as shipping the vehicle back to Britain and so forth

ACKNOWLEDGEMENTS

We acknowledge with thanks assistance from the following people:

Our Patrons

Our Contributors

Sir Frederick Gamble, British Ambassador to Bolivia

Mr. D.G. Crichton, Head of the Chancery, British Embassy, La Paz

The Staff of the British Embassy, La Paz

Sr. V. Mendez Baya, Charge d'Affaires, Bolivian Embassy, London

Ing. Fadrique Munoz Reyes, Minister of Mines and Petroleum, Bolivia

Ing. Jose Bustamante Borda, Ministry of Mines and Petroleum, Bolivia

Ing. Jorge Munoz Reyes, Universidad Mayor de San Andres, La Paz

Ing. Gaston Pereira Bascope, Director of Geobol

Senorita Beatriz Aristain, Secretary to the Director

Ing. ISmael Montes de Oca, Geologist at Geobol

Ing. Salamon Rivas, Geologist at Geobol

Mr. R. Anderson, U.S. Aid Advisor, Geobol

Mr. P. Wright, Instituto Minera Metalurgigo, Oruru

Mr. L.Z. Makowiecki, United Nations Geological Survey

Mr. Charles E. Johnson, Director, British Tropical Agriculture Mission to Bolivia

Mr. C.R. Howell, British Tropical Agriculture Mission

Mr. John Payne, Martin and Company, La Paz

"Incatur" South American Travel Agents in La Paz

Ing. Mario Guillermo Arnaza Aliaza, Bolivian National Railways, Uyuni

Sr. Crispin Huanca, a friend in Uyuni

Sr. Manuel Ramos Lopez, School teacher, San Pablo de Lipez

Sr. Alfedo Sosa, Administrator of La Mina Bolivar

Mr. M.J.S. Neville, Director, Lobitos Oil Company, Talara, Peru

Mr. F.R. Whaley, Burmah Oil Company

The Officers and Crew of "El Lobo"

Mr. I.C. Jewitt, 2nd Officer, "El Lobo"

Mr. C.N. Griffis, Editor, Peruvian Times, Lima

Dr. J.H. Briggs (our Medical Advisor) Charing Cross Hospital

Colonel M.M. Lewis, Royal Army Medical Corps

Mr. H. Beard, Principal of Mineral Resources Division, Overseas Geological Survey

Mr. D.S. Paterson, South American Specialist, Overseas Geological Survey

Mr. D.R. Hunt, South American Specialist, Royal Botanic Gardens, Kew

Miss W.M.A. Brooke (British Museum)

Arequipa Ladies Basketball team

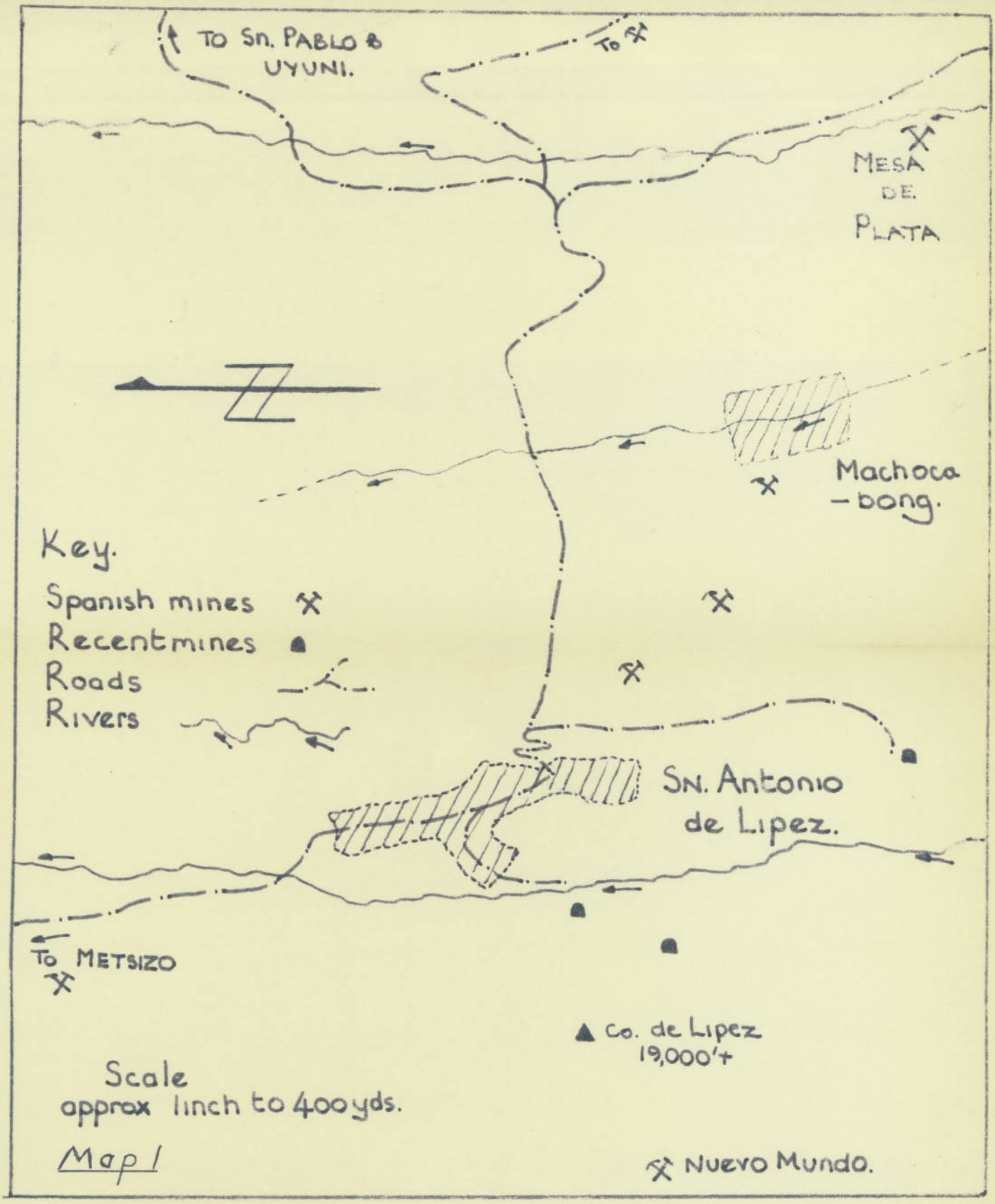
Van Ommeren P.H.S. (London) Ltd., Travel Agents

Pacific Steam Navigation Company Ltd.,

Mr. P.J. Cram, Imperial College

Mr. B. Edwards, Imperial College.

Finally we would like to record our thanks to Miss L. Hull and Miss C. King for their efforts in typing and producing this report.


TO Sn. PABLO & UYUNI.
To
MESA DE PLATA
Machoca - bong.
Key.
Spanish mines
Recent mines
Roads
Rivers
Sn. Antonio de Lipez.
To METSIZO
▲ Co. de Lipez 19,000'+
Scale approx 1inch to 400yds.
Map 1
Nuevo Mundo.