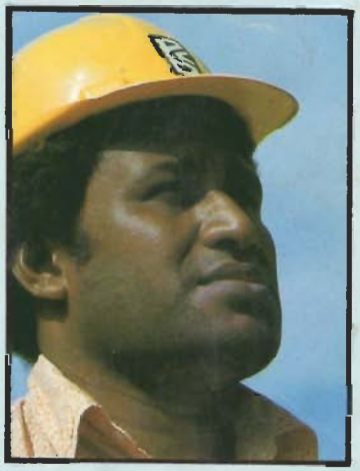
BOUGAINVILLE COPPER



Introduction

High in the tropical rain forests of Bougainville's Crown Prince Range, Bougainville Copper Limited has established one of the world's major open cut mines to work the Panguna porphyry copper deposit.

From discovery to commissioning took eight years: five years of evaluation and planning, then three years of construction.

From the start, the Company saw the project as a partnership between overseas investors and the Papua New Guinea Government, and a partnership utilising the best of expatriate and national skills.

A 400 million kina investment, the mine began commercial production in April, 1972. Large by any standards the mine provides close to 100,000 tonnes of ore a day for processing to copper concentrate – a premium product because of its additional gold and silver content.

Development of the Panguna mine has not only contributed to the development of Bougainville Island, but it has brought many benefits to the nation of Papua New Guinea.

In the first year of operation, copper concentrates from Bougainville trebled the nation's annual exports. Company operations have generated new levels of Government revenue through taxation and mining royalties.

Increased trade and Government revenues have contributed to the welfare and improving living standards across the new nation, while the Company's operations have provided opportunities to develop new skills and expertise for thousands of Papua New Guineans. Four in every five people employed by BCL are Papua New Guinea nationals.

The operation is fully geared to Papua New Guinean conditions. The Papua New Guinea Government is a large shareholder (20%) together with the public (26%) and the original discoverer of the mine, Conzinc Riotinto of Australia Limited (CRA) (54%).

With an expected life of 30 years, the Bougainville Copper Mine at Panguna is an important force in shaping a developing nation.

Panguna mine.

History

The early settlement of the Solomon Islands by the Melanesian people will never be fully revealed but patient anthropological and archaeological research may eventually produce a broad understanding of the past.

The first European to sight the island was Louis de Bougainville, commander of French vessels "La Bordeuse" and "L'Etoile". On the 4th July, 1768, the two ships sailed along the east coast of the island, Bougainville noting in his journal the existence of mountains of prodigious height behind the new coast and giving the island its geographic name.

The next recorded visit to the island was not until 1792 when another French explorer, Bruny D'Entrecasteaux called at Buka and reported that the friendly islanders were keen to trade.

From that time on the island appears to have been a frequent calling place for trading vessels, sealers and whalers. Islanders traded smoke dried copra for weapons, metal tools, tobacco, cloth and liquor with the European and American visitors.

The late 19th Century was a dismal period when many Solomon Islanders were recruited to work on plantations in Fiji, Samoa and Queensland.

Expansion of imperial Europe brought Bougainville and New Guinea into the German Empire in 1884. However, it was some time before German traders, missionaries and the administrators arrived in Bougainville. An administrative office was not established on the island until 1905 and the first plantation began production soon after.

Declaration of war between Germany and the British Empire in 1914 promptly led to the occupation of Bougainville by an Australian military force. Following the war the former German colony of New Guinea became a League of Nations mandate under the care of Australia. Extensive coconut and cocoa plantations were developed and in the 1930s, several small gold fields were discovered on the island's mountain backbone.

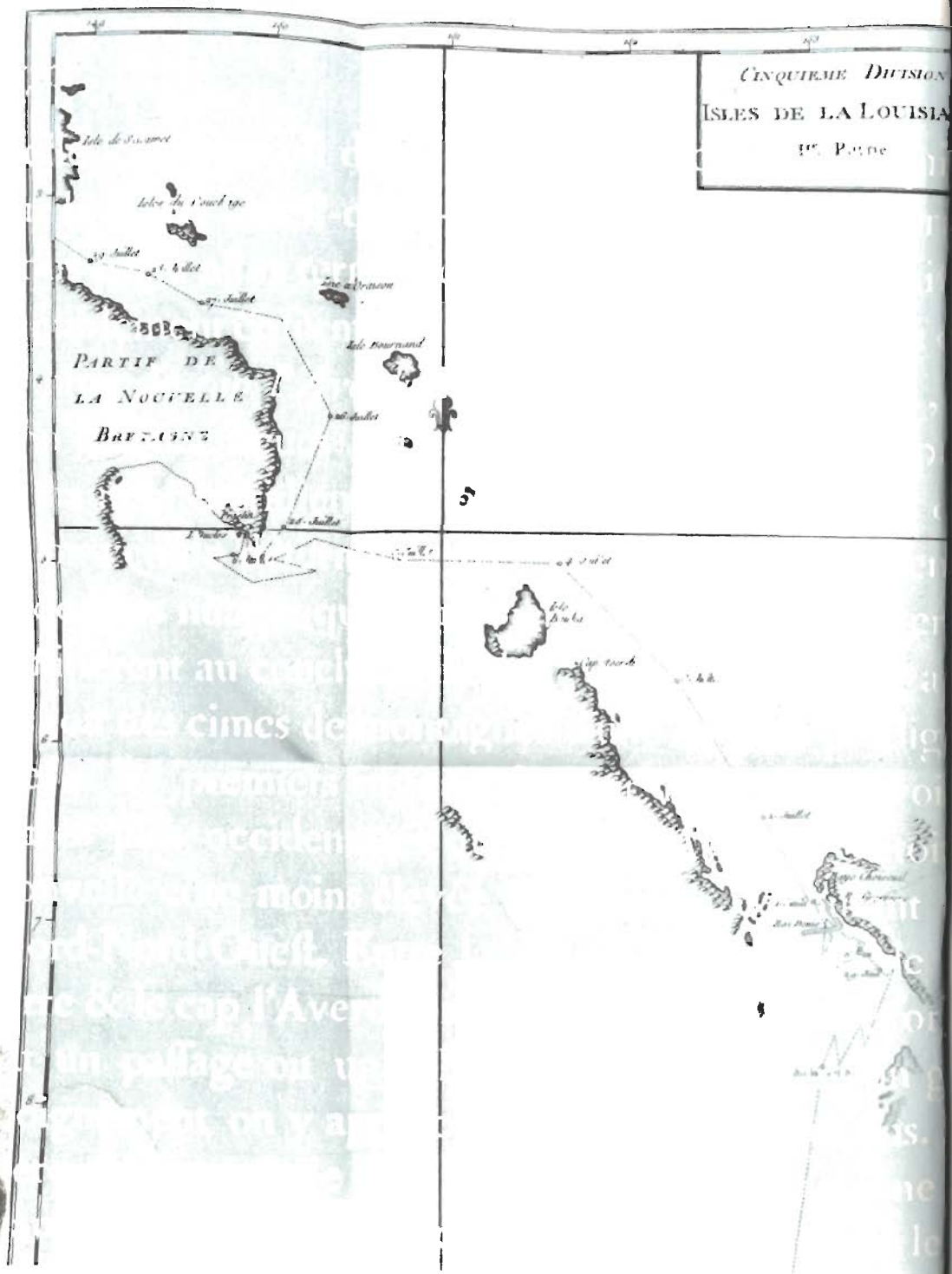
During World War II the island saw bitter fighting between Japanese and Australian forces and for a short time Bougainville was occupied by the Japanese.

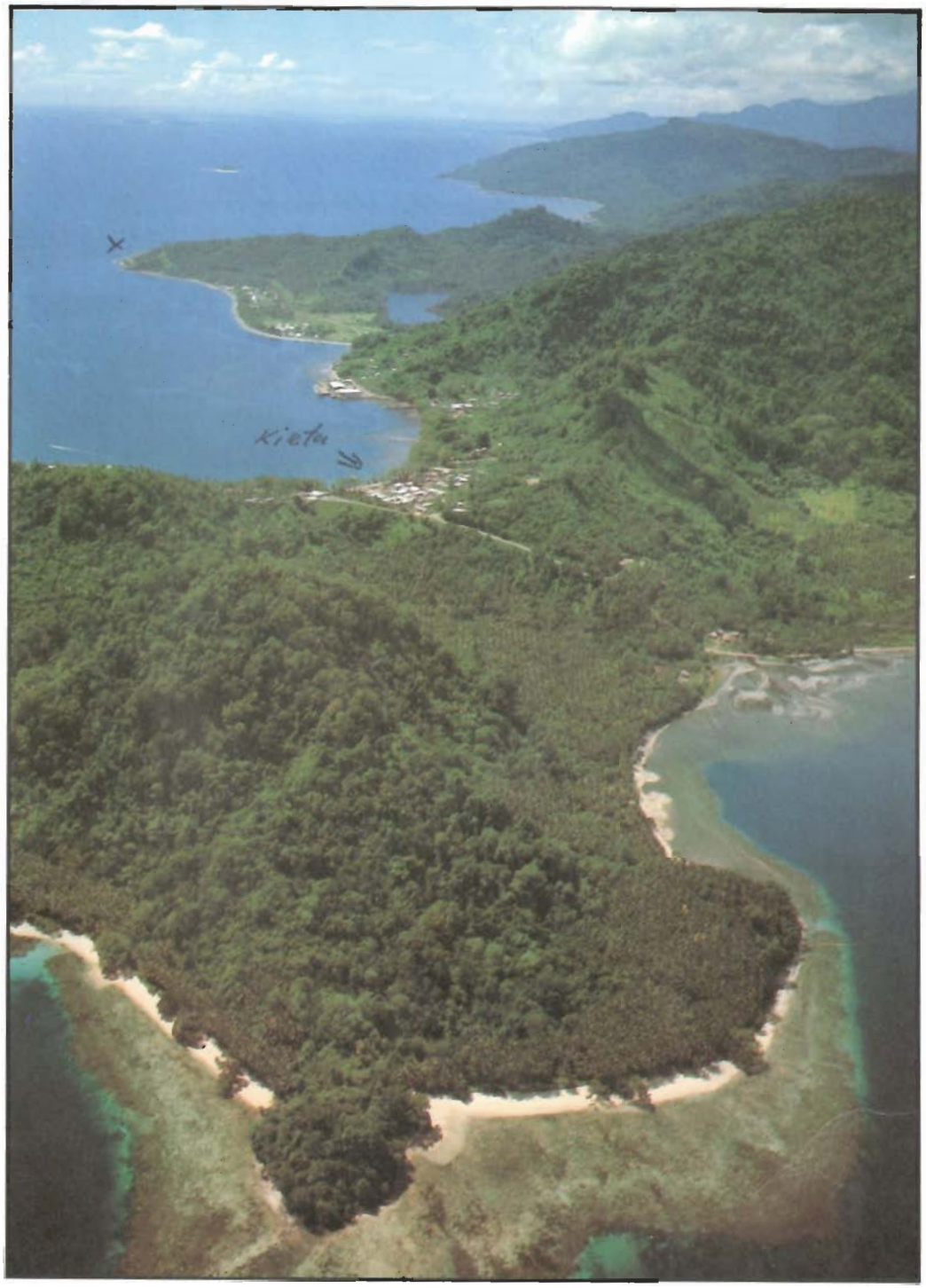
Like many other Papua New Guineans during this time of conflict, Bougainvilleans suffered. Subsistence living was made extremely difficult due to the large number of troops in the Bougainville Islands. At one stage there were 65,000 Japanese troops at a time when the Bougainvillean population was estimated at only 45,000.

In 1945 the Australian civil administration was re-established and Bougainville along with the rest of the mandate became a United Nations Trusteeship territory. Copra and cocoa plantations continued to provide the major source of revenue but in 1964 the discovery of copper promised major changes for the island. Eight years later a major porphyry copper mine was commissioned by Bougainville Copper Limited at Panguna.

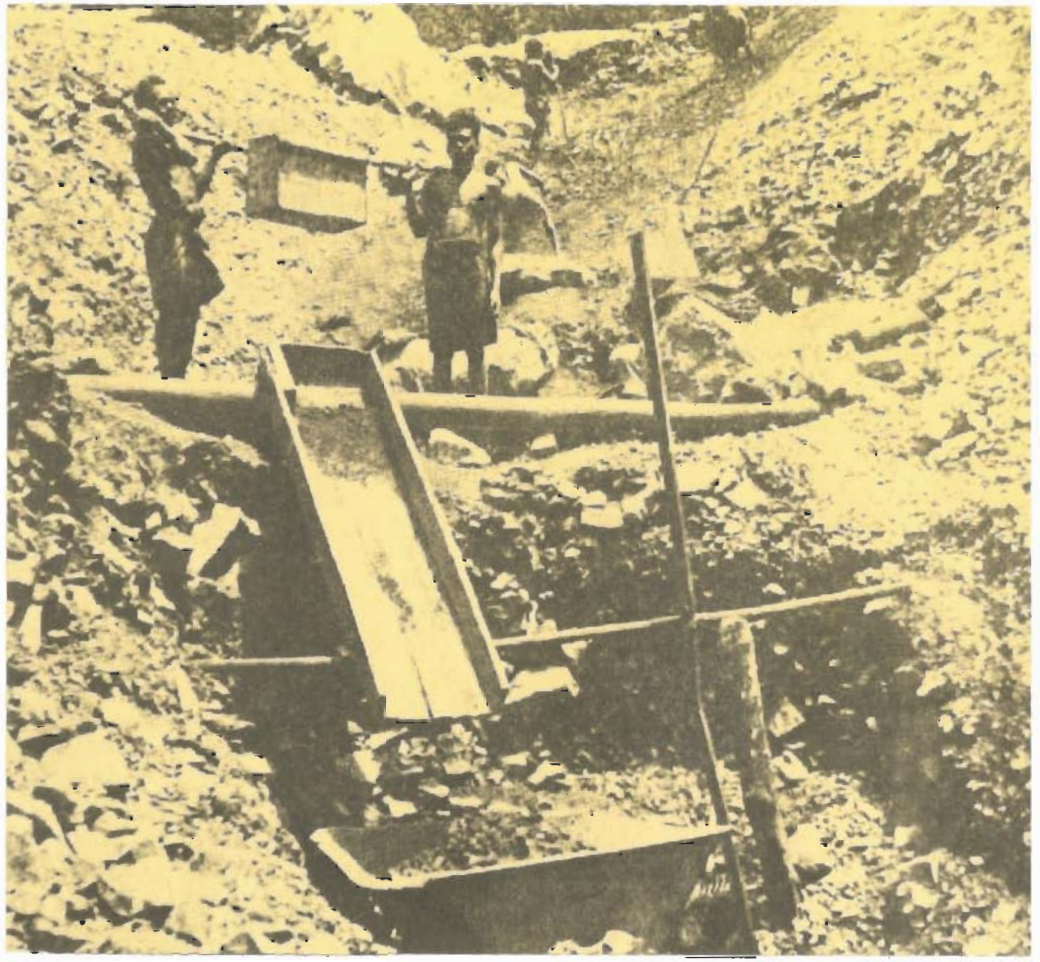
Initially movement towards nationhood was slow but from the late 1960s Australian policy was geared to prepare Papua New Guinea for independence. In 1973 Papua New Guinea gained self government and in 1975 it became a sovereign state. Bougainville and surrounding islands became The North Solomons Province in the new nation.

Louis de Bougainville.





Palm plantations near Kieta.



Gold mining, Kupei.

Exploration and discovery

Miners first came to Bougainville searching for gold in the wake of the New Guinea gold rush immediately after the First World War. Prospectors Jack Comb and Bob Palmer discovered gold in the dense rainforest of the Crown Prince Range at Kupei. A small mine was established there as well as others at nearby Moroni and Panguna and along the Kawerong River. But the gold was difficult to win from the copper ore and the prospectors remarked grimly that there was gold on the island – but there was too much Bougainville in it. Gold valued at nearly K60,000 was won from the Kupei field, but mining tapered off in the early 1950s.

A report on the Panguna Gold Copper prospect produced by the Australian Bureau of Mineral Resources in 1961 was the beginning of CRA's interest in the area.

CRA had begun exploring specifically for porphyry copper in Queensland and although its Australian search was unsuccessful, much experience was gained, resulting in further exploration in Papua New Guinea in 1964.

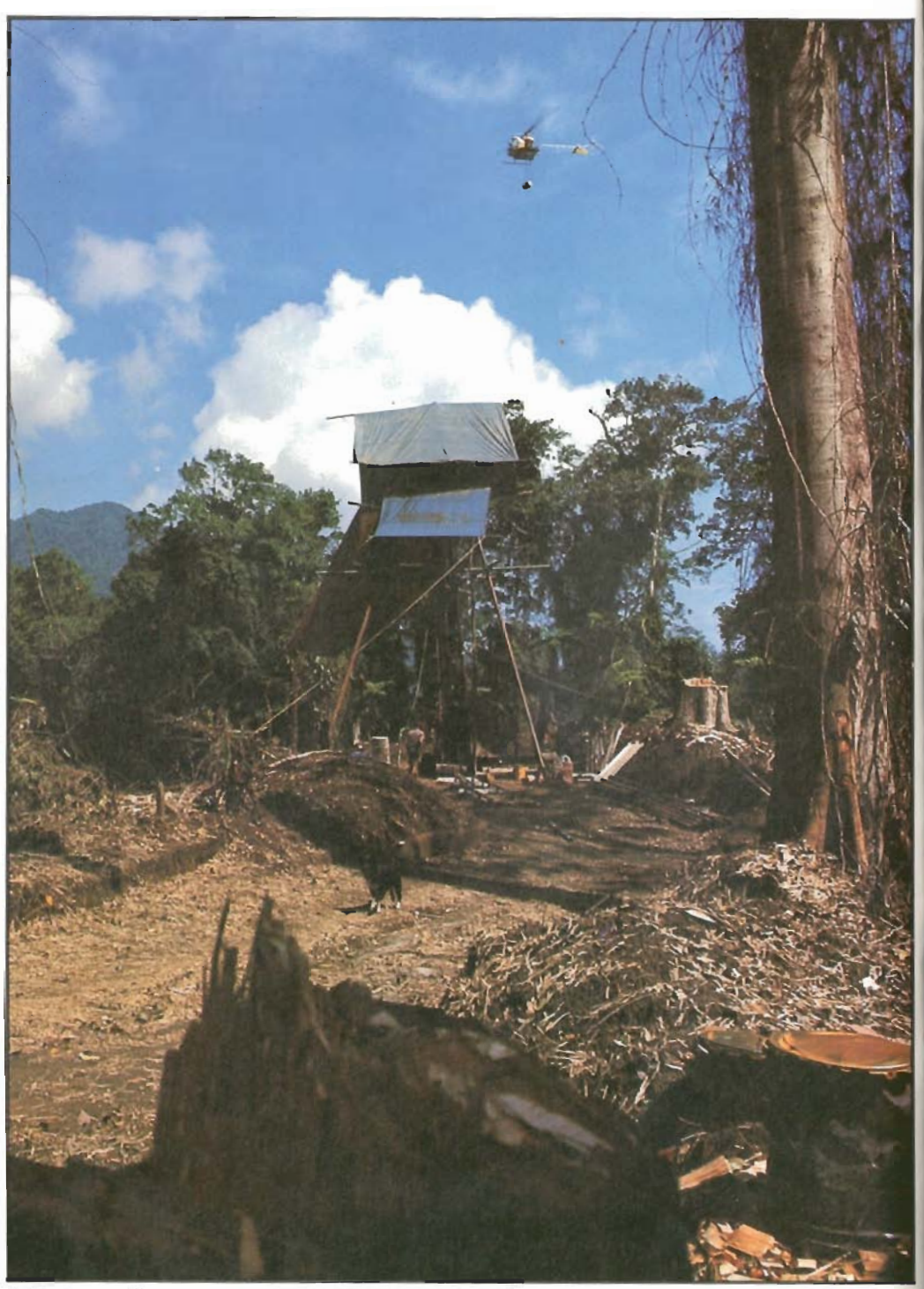
The Panguna deposit was discovered largely as a result of this earlier experience and following extensive investigations of the several prospects identified in Mines Department records.

The CRA geologist, Ken Phillips who was in charge of the exploration team working in Papua New Guinea, walked into Panguna Valley on 1st April, 1964. Light drills were manhandled across the 1,100 metres high divide by the exploration crew in November 1964 to do the initial drilling. In mid-1965 heavier drills were flown in by helicopter.

Initial samples were promising but it took years of exploration, drilling, proving, evaluation, engineering feasibility and marketing and financial studies before a final decision was made to develop a mine.

During this period two main facts emerged. Firstly, the deposit was low-grade, so it was clear that very large ore reserves were needed to feed a plant which would give the required economies of scale. Secondly, it was obvious that there would be a high degree of involvement with the local Bougainville people living mostly in scattered village communities.

Eventually an economic orebody was established, consisting of 900 million tonnes of ore of less than .5% copper with some gold and silver, while problems of access, terrain, high rainfall and lack of infrastructure were studied and overcome. In 1969 the go-ahead was given to develop a copper mine at Panguna and to have it in operation in 1972.



Helicopter supplies.

Exploration site, Pan Ridge.

Planning & evaluation

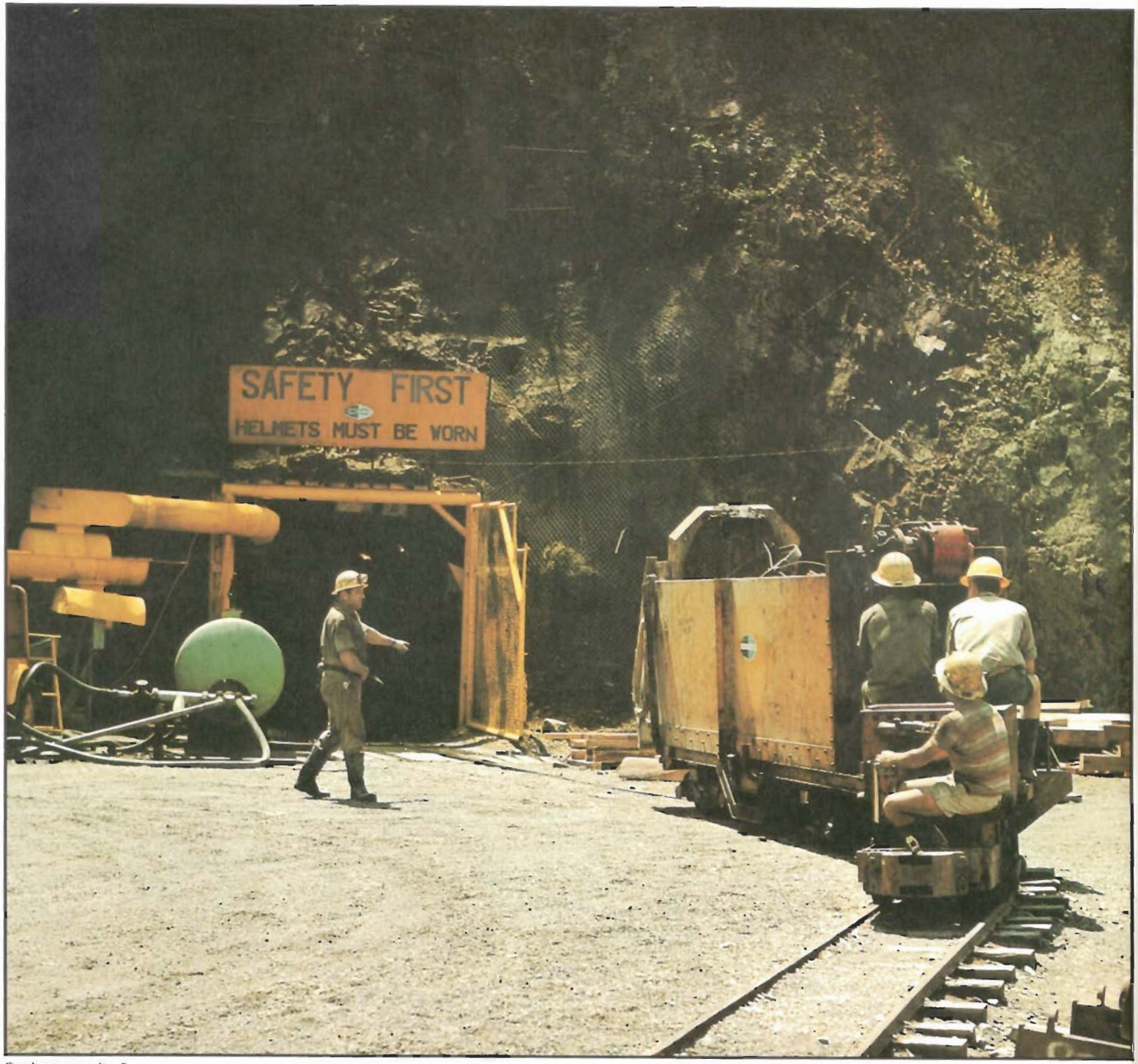
The project exploration and feasibility studies occupied 5½ years, required extensive use of computerised systems and had to be undertaken against a background of change as constant monitoring and updating of data. The cost of the work to the company was K21 million.

An important factor in planning the Bougainville operation was the early decision that the deposit should be mined and that the Papua New Guinea Government, on behalf of the people, should be a partner in the project.

Evaluation of the proposed Bougainville operation demanded knowledge of geology, mining, metallurgy, engineering, marketing, economics and personnel aspects, the ability to draw these together, to anticipate variations and to superimpose such intangibles as environmental, political and social factors.

Economic feasibility of the Bougainville operation was established in July 1969 and was finalised in October of the same year when financing arrangements, involving the raising of some K130 million in equity capital and K260 million in loan capital, were completed.

Given that technical and commercial factors interacted favourably to indicate feasibility, the next key planning stage involved design and engineering of the plant and the necessary infrastructure items such as port, roads, towns and power supply.



Exploratory adit, Panguna.

Construction

Construction of the Bougainville Copper facilities took 33 months, some three months less than scheduled.
In all, construction involved a workforce of up to 10,000 people who worked a total of 53 million man hours to complete the project. They were faced with testing obstacles: a tight schedule, remoteness of the mineral deposit, the rugged terrain, unstable soil, seismic activity, and a tropical climate with a high rainfall.

In view of the large outlay of capital funds there was always the prime challenge of TIME — to build it to specifications and to build it to schedule. Besides this were the more particular and the individual challenges. These ranged from the concerted 'back room' efforts involving procurement, shipping and design through the special problems of building a permanent port-mine access road over a steep and unstable mountain range to single challenges such as finding solid foundation for the power station and gaining access to a rock mountain required as a quarry for aggregate.
Construction and assembly of crushing, grinding and concentrating facilities occupied some 14 months. Although often hampered by the heavy rainfall, progress was excellent.

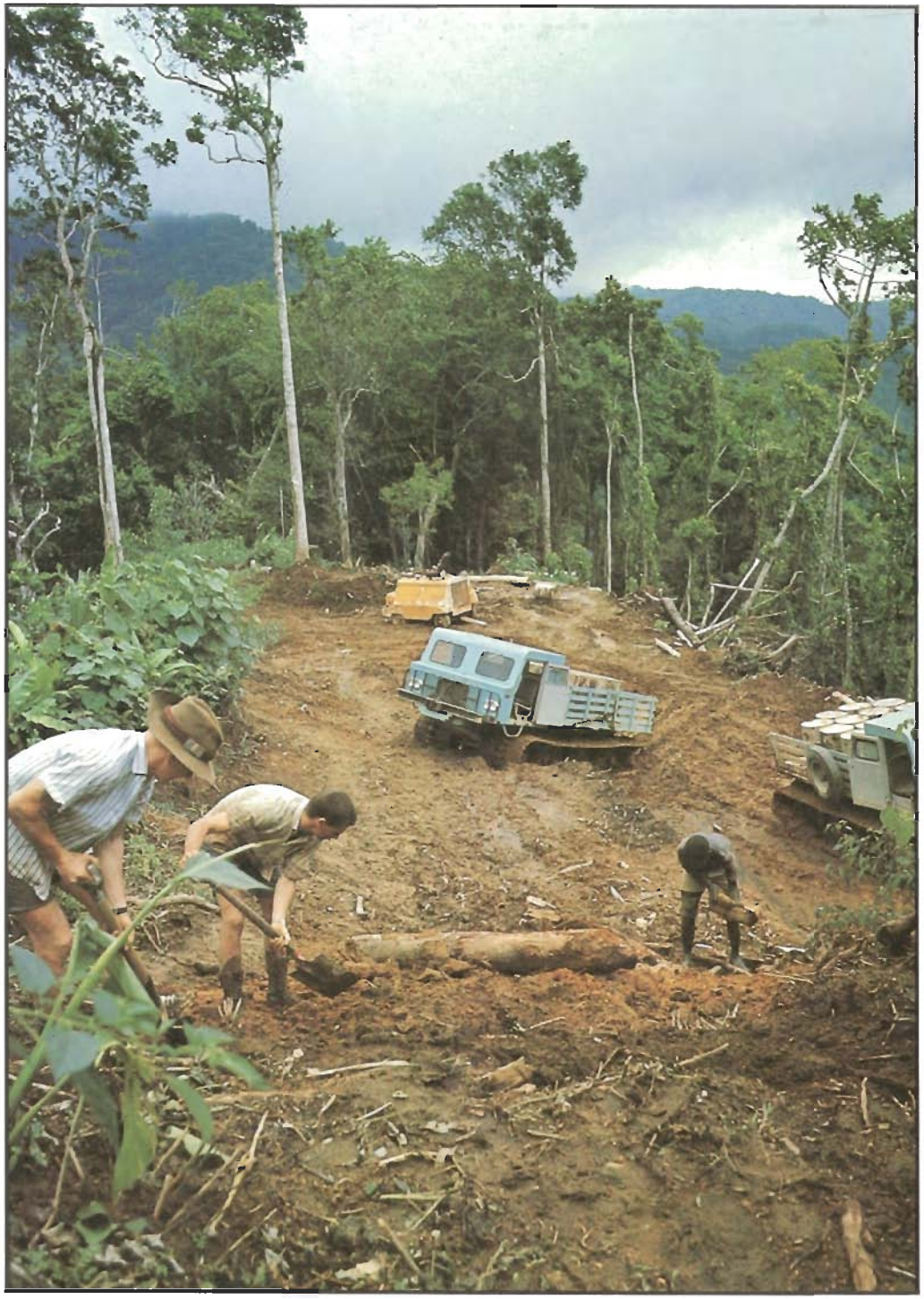
Testing and commissioning of the production components were completed during the first quarter of 1972. Commercial production of copper concentrates commenced in April 1972.

Infrastructure

In planning the Bougainville project the Company was faced with a total absence of infrastructure facilities to service the mining operation.

Support facilities for the mine and processing plants were equally important in the construction phase. In addition to roads, the Company built a new port at Anewa Bay, a power station also at Anewa Bay and a town at Panguna. It shared the building of a second town, Arawa on the east coast with the Papua New Guinea Government.

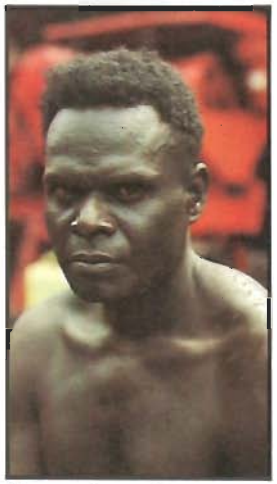
Some K145 million or 36% of total company expenditure was spent on mine infrastructure.



Early roads.

Early harbour works.

Cutting the Panguna road.



Construction worker.

Roads

Access to the Panguna area was difficult until the completion of a temporary access road in late 1967. Before then, geological teams used either jungle tracks or helicopters.

By early 1971 the access track was upgraded to a two lane 7.4 metre wide highway with a maximum gradient of 12 per cent. Construction of these roads was a major engineering project. Because of the steep and unstable terrain, slips and mud flows were commonplace. Ten million cubic metres of rock and soil were excavated on the project.

The completed road permitted ready transport of materials from the port and personnel from the new town of Arawa to the minesite.

Other major roads constructed were the coastal highway linking Anewa Bay and Kieta, the road from the mine to the Jaba River pump station and the complex road and street system at the mine and Panguna township.

Heavy traffic on the temporary Panguna road.

Completed Panguna highway.

The Port

Anewa Bay was chosen as the port site because it offered sheltered water suitable for bulk ore carriers of up to 45,000 dwt. Although the port is well protected by the offshore reef system, a careful study was made of the frequency of freak waves or Tsunamais in the region. This resulted in all the port facilities — warehouses, the fuel tank farm and the copper concentrate filtering and drying plant being located above any expected maximum wave height.
The port received its first ships in August 1970.

Power station

Hydro electric power was seriously considered for the project, but studies favoured an oil fuelled steam turbine power station.

A port location was deemed most practical given the reliance on imported fuel oil.

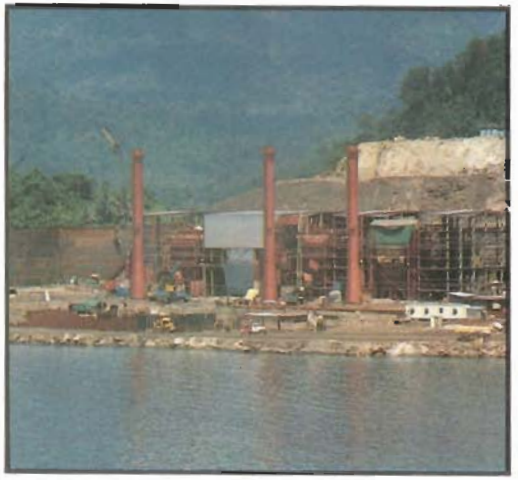
Until the power station was completed, temporary plant with a generating capacity of 11 MW was established to allow for the operations of shovels and drills to begin in late 1970.

Commissioned in November 1971, the power station comprises three 45 MW boiler turbine generators which are seawater cooled. In addition to supplying electricity for the mine operations, the power station also supplies Panguna, Arawa and Kieta.

Construction at Anewa Bay.

Wharf construction.

Concentrate storage shed.



Power house.

Accommodation

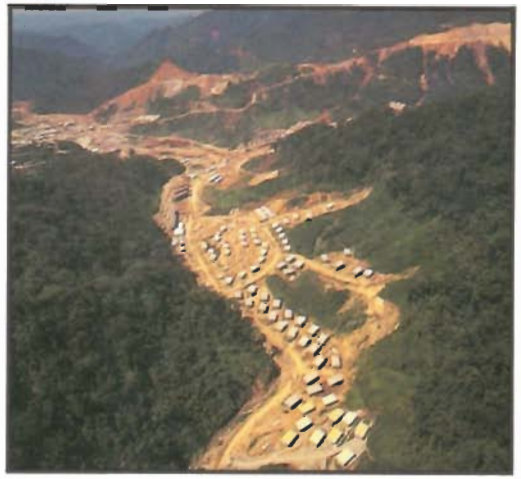
Development of the mine meant that accommodation had to be provided for a workforce of up to 10,000. Eight temporary camps were built and where possible, the accommodation for the construction workers was designed for use by the permanent employees once the mine was commissioned.

When fully operational the mine and support facilities would employ some 4,000 men and women. Employees and their families were to be housed at two new towns; Arawa on the coast and Panguna at the mine site.

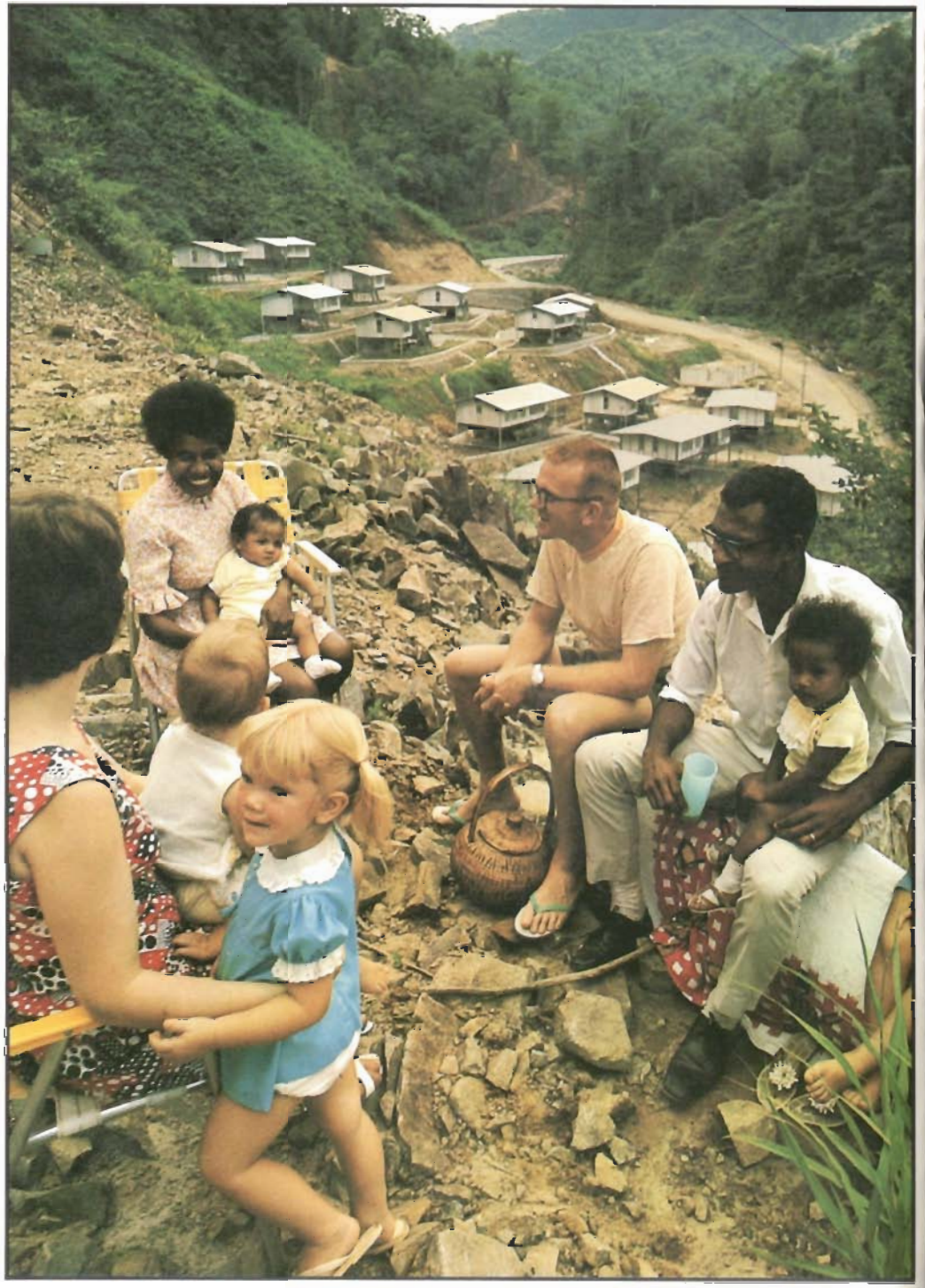
Arawa is located on low lying coastal flats and large quantities of earthfill were needed before subdivision and construction commenced. The initial development of 2,000 home sites was undertaken by Bougainville Copper in conjunction with the Papua New Guinea authorities, with subsequent expansion. The Company has now built over 1,600 homes. Planning was on the basis that the town would have a population of 10,000 by 1985.

Panguna by contrast was solely a Company responsibility. Nearly 400 homes, 6 blocks of flats and 10 blocks of units for the single employees were built together with the normal facilities of a small town: sporting facilities, shops, school, church, library, community hall, kindergarten, police, fire fighting unit and ambulance service.

Panguna under construction.



Arawa under construction.



Family housing, Panguna.

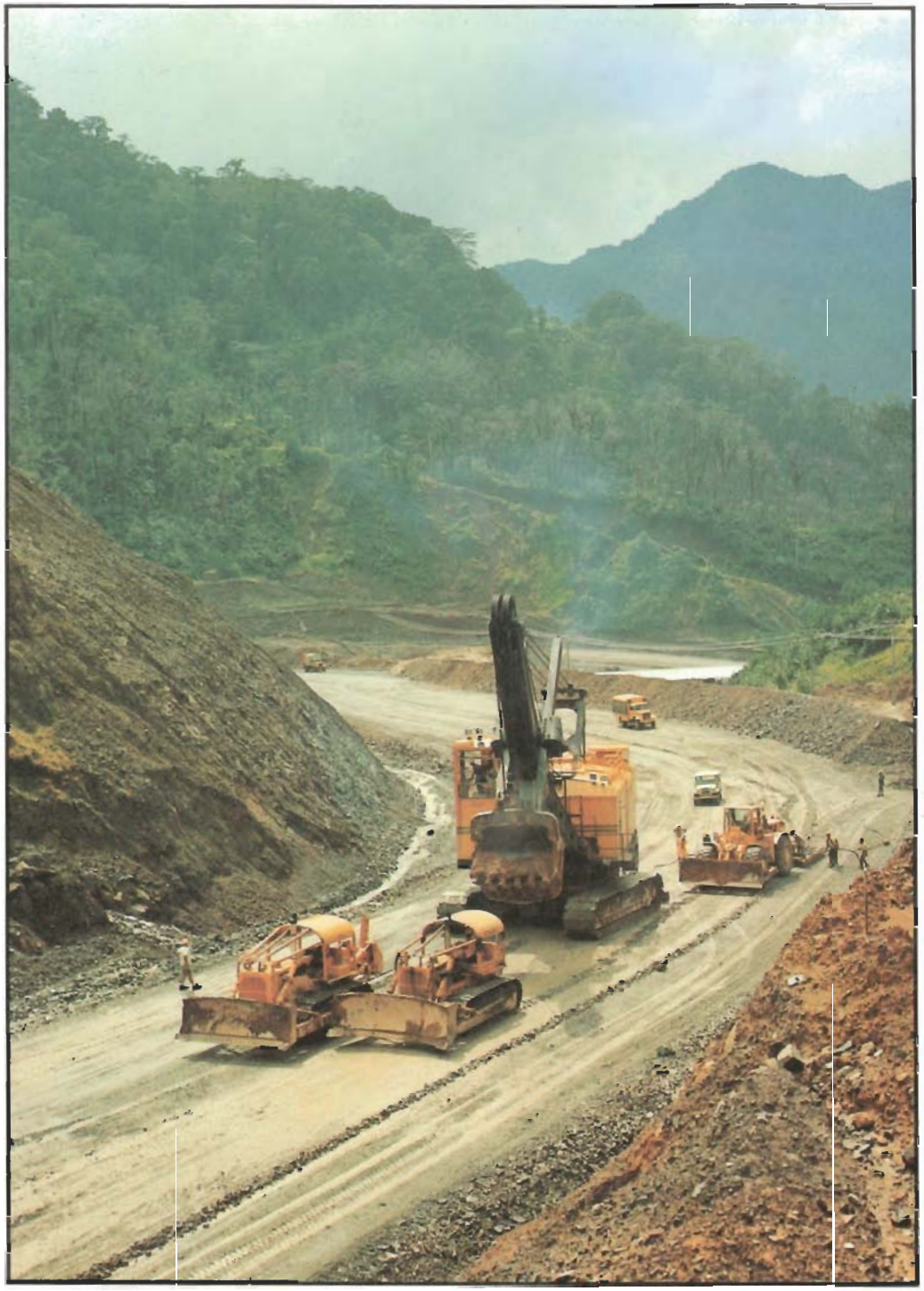
Mine

Overburden covering the copper orebody at Panguna varied from 0-60 metres over an area of 200 hectares at the Panguna mine site. This had to be moved before mining could commence. Composed of volcanic ash, the soil could not be moved by conventional equipment and a technique called hydraulicking was adopted. Bulldozers were used to push the overburden into natural drainage channels and the material was washed away using large hydraulic hoses. Over 13.2 million cubic metres were removed using this technique between 1969 and 1971.

Truck and shovel stripping of the pit area in preparation for actual mining began in November 1970. This was a priority that called for careful co-ordination within the general construction and procurement program. Essentially the mine had to be developed to a stage where it could meet the full demand for ore by the time the concentrator was commissioned.

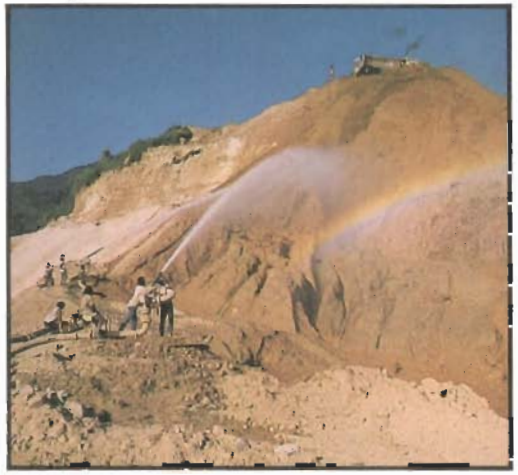
Meeting the target was not only a case of landing the equipment, but also training operators for the truck, shovels and drills. The road to Panguna had to be sufficiently advanced to allow the heavy mine equipment to reach site at the time planned.

One of the most satisfactory parts of this exercise was the concentrated training program which provided national drivers with the ability to handle the giant sized trucks from the beginning of operations. Total localisation of shovel, drill and heavy equipment operators was achieved by the commencement of production.



Moving heavy equipment to the mine.

Sluicing.



Mining ore. *Above centre: Removing the overburden.*

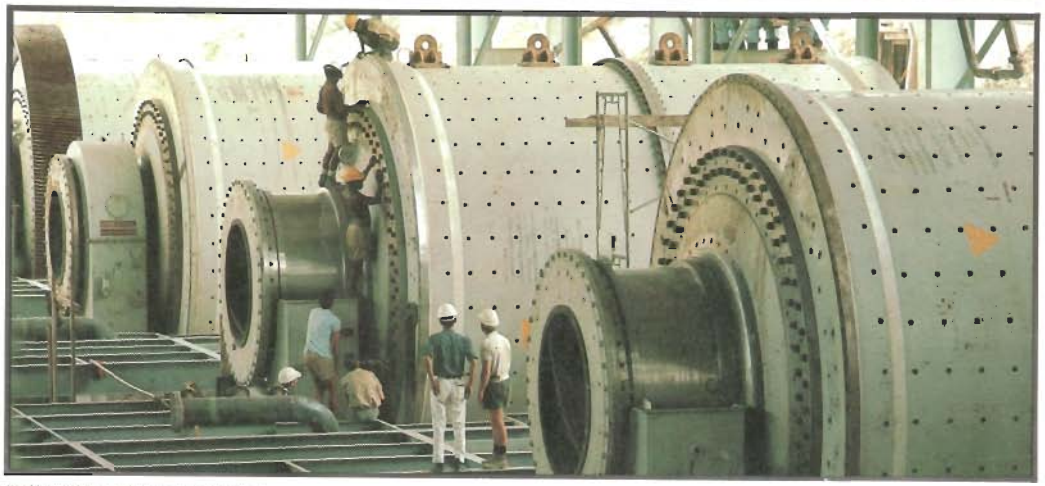
Process plant

Design and construction of the process plant ran in parallel with the development of the mine and the provision of infrastructure. This incorporated facilities for crushing the ore, concentrating the metal content and transporting the concentrate to the point of shipment.

Initial design criteria were for a plant throughput of 80,000 tonnes per day. This made Bougainville's concentrator the largest to be constructed in a single stage. Expansion to the current capacity was undertaken subsequent to initial construction.

In designing the plant, the Company enlisted the services of international engineering organisations with specialist expertise. Not only had the plant to provide for the mass handling of materials in a process optimising metallurgical recovery, but also it was to be constructed in an area of considerable seismic activity.

Ore conveyor under construction.



Ball mills under construction.

Early view. Panguna mine, township beyond.

Operations flow chart – from mine to port

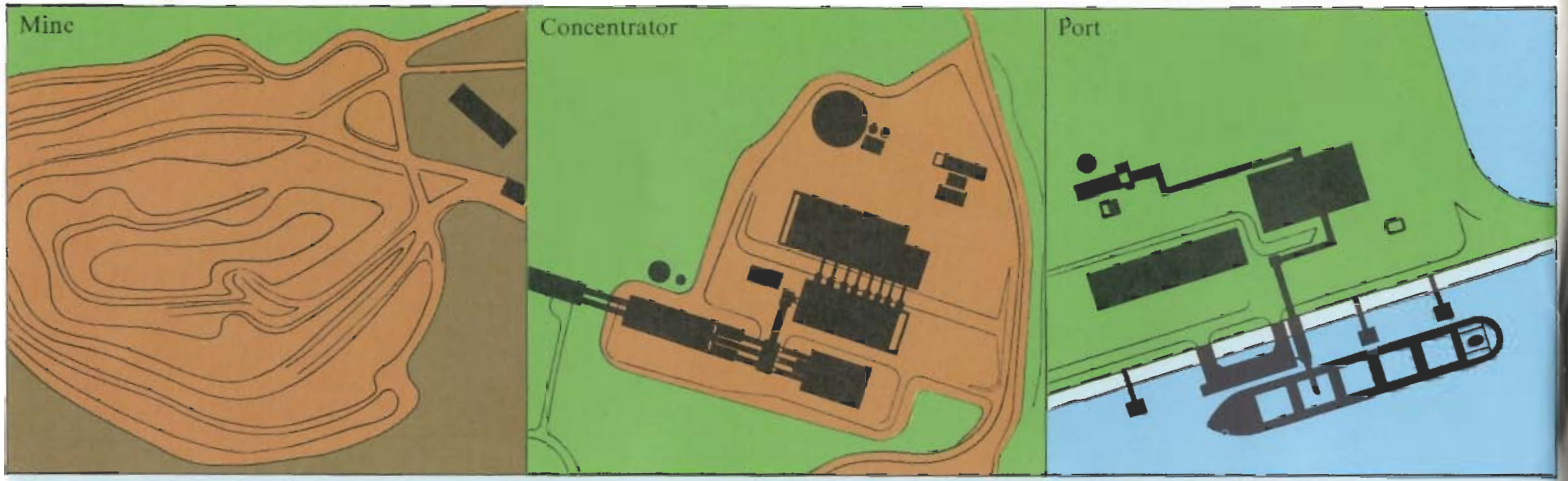
The Bougainville Copper operation converts the low grade ore into a marketable concentrate containing about 30% copper with some gold and silver.

Equipment and processes used are conventional in all aspects except volume of material treated. It is only by treating large volumes that this low grade of ore can be processed economically.

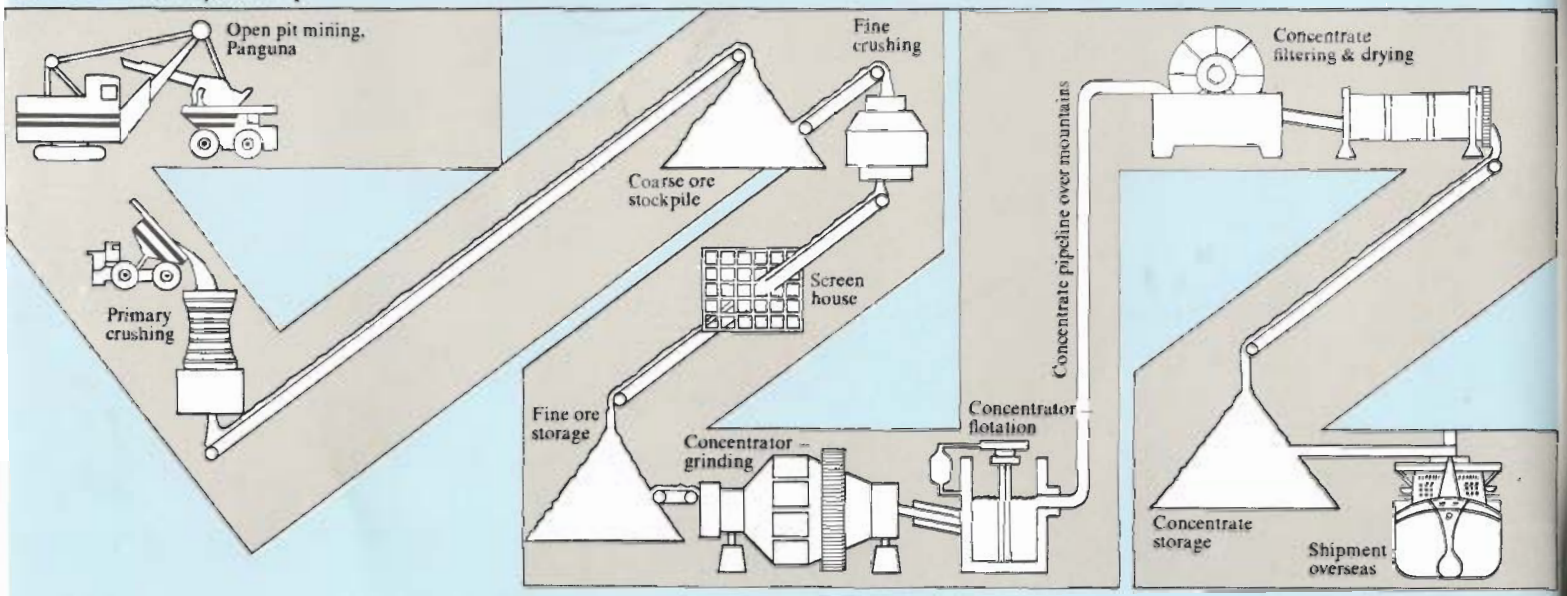
At the mining stage material is classified as ore or waste depending on the content of metals. Waste material, where metal content is below the level that can be processed economically through the concentrator, has to be removed and placed on waste dumps where it does not interfere with future mining operations. The material with high metal content which is classified as ore is dumped into the primary crusher.

Thus begins the treatment process where the ore goes through a series of crushing and grinding stages to reduce it to fine particles. The particles of metal are separated from the particles of rock by a flotation process.

Concentrate in solution is then thickened into a slurry, pumped to the port, dried and stockpiled awaiting shipment. An average of 2 to 3 ships are loaded each month for supply to the Company's overseas customers.



Flow of ore from pit to ship



Mining at Panguna

Had the Panguna deposit been discovered 10 years earlier mining would not have been economic. The copper grade average of 0.48% placed the ore firmly in the low-grade category, demanding an unusually high rate of throughput for a new mine, to ensure viability.

Mine planning has been geared to this requirement both in the clearing and stripping program preceding production and in the current operating era. The supply of ore to the plant and concentrate to overseas markets resulted from sophisticated planning procedures.

On an average day some 200,000 tonnes of material are mined from the Panguna open pit. About half of this is ore. Mining operations are continuous with three eight hour shifts per day seven days per week.

The use of modern mining equipment is an important factor enabling the large tonnages to be won and handled continuously. Pit equipment includes nine 22 tonne capacity P & H electric powered shovels, five Bucyrus Erie 45R electric drills and 43 Euclid dump trucks each capable of carrying 150 tonnes.

Grade is not uniform throughout the orebody. Penetrating an oxide crust reduced recovery in the early months of mining, but in general, problems in mining at Panguna have been few.

Progress in the mine area naturally will deepen and widen the pit dimensions which, ultimately, are expected to measure approximately 2,300 metres by 1,600 metres by 300 metres deep.

Night shift

Crushing the ore

Treatment of the Panguna ore begins with crushing, involving three phases, to reduce it to a size suitable for grinding in ball mills. Primary crushing produces a coarse ore about 160 millimetres in diameter which is further reduced to less than 12 millimetres by secondary and tertiary crushing and screening. The fine ore is then stockpiled before being fed to the ball mill circuits.

The primary crusher is located alongside the mine area and is actually two gyratory crushers which may operate in parallel or independently as required. The fine crushers (8 secondary and 14 tertiary) together with the adjoining screening plant are almost a kilometre distant in another valley, this circumstance arising from the scarcity of flat ground in the Panguna area.

Connection from the primary crusher to the stockpile feeding the fine crushers is by two 1.37 m. belt conveyors which lift the coarse ore 170 metres higher in carrying it to the stockpile. The conveyors are covered against the effects of the heavy rain. Installations and extensions included one secondary and two tertiary crushers, extra screens, extended lengths and speeds of conveyors and additional dust cleaning equipment which has further improved plant hygiene standards.

Concentrator

Bougainville Copper's concentrator is the largest copper concentrator in the world to be designed and built as a single unit.

The building, with other processing structures at Panguna, was designed and engineered to modern international standards, taking into account the seismic activity experienced in the Bougainville region.

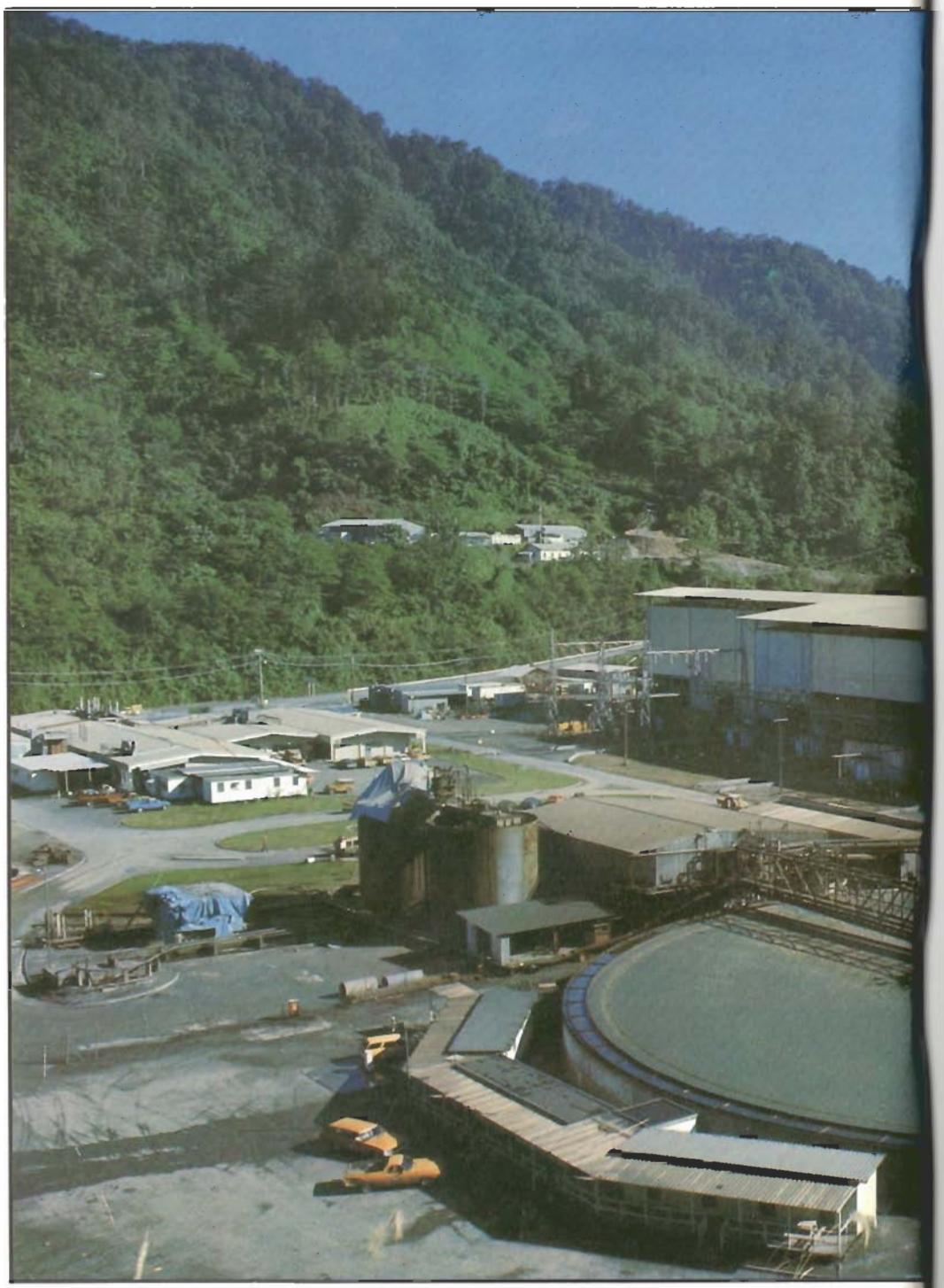
Production of a concentrate from the fine ore is achieved by grinding and flotation. The first stage is the grinding of the ore in ball mills until fine sand-like particles are produced. The Panguna operation utilises ten ball mills; nine of these mills are 5.5 metres diameter by 6.4 metres long and the tenth mill which was added later is .9 metres longer.

Coarse ore stockpile.

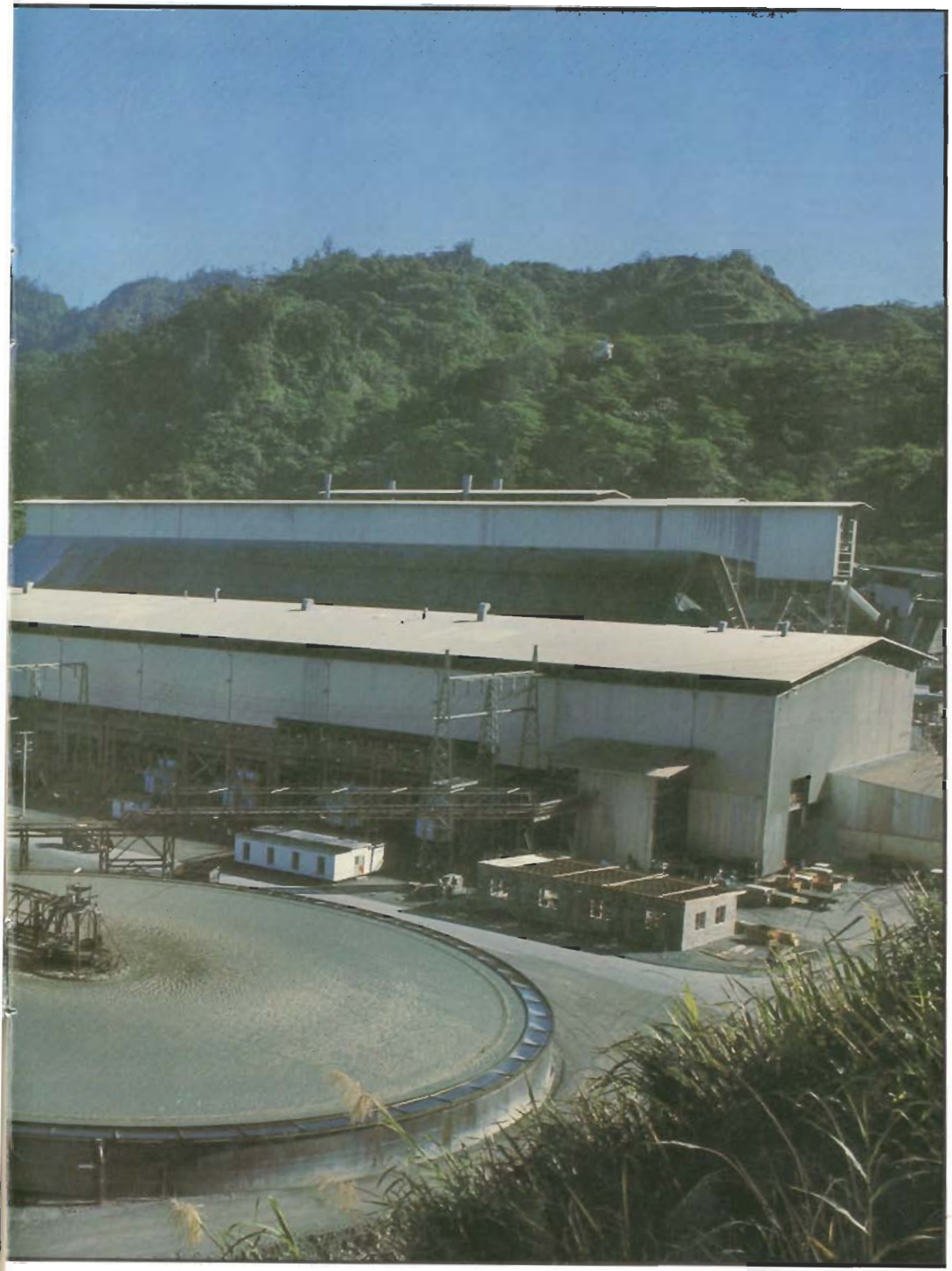
The second stage of concentrating is flotation. In this process the ground particles from the ball mills are agitated in water containing reagents with low pressure air added. This results in separation of the copper minerals as well as gold and silver from the rock and production of a concentrate containing about 30% copper.

The Panguna concentrator has 333 flotation cells with a total capacity of 2,166 cubic metres.

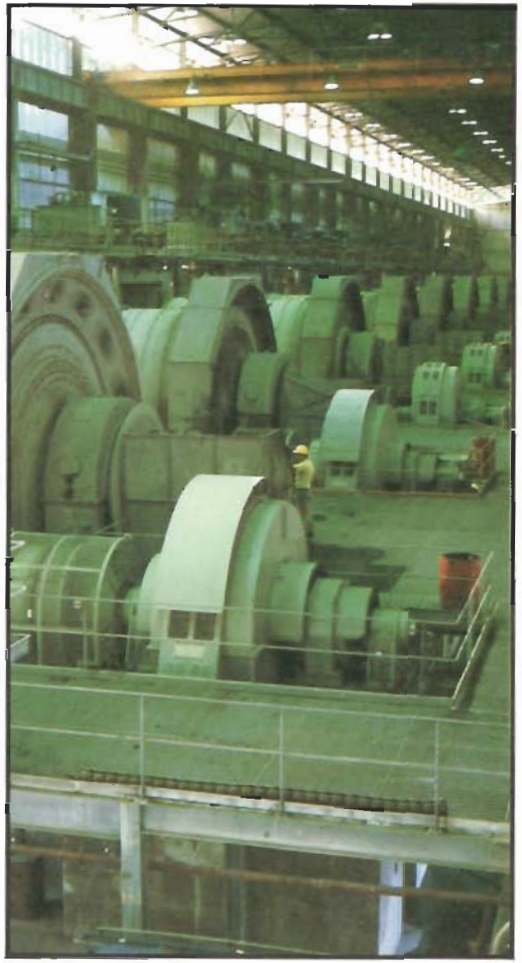
Milling and flotation require a water supply of 136,400 cubic metres a day. (Despite Bougainville's 4,500 mm annual rainfall, securing of this water supply – by construction of pump stations on the Jaba and Kawerong Rivers – was a vital task.)

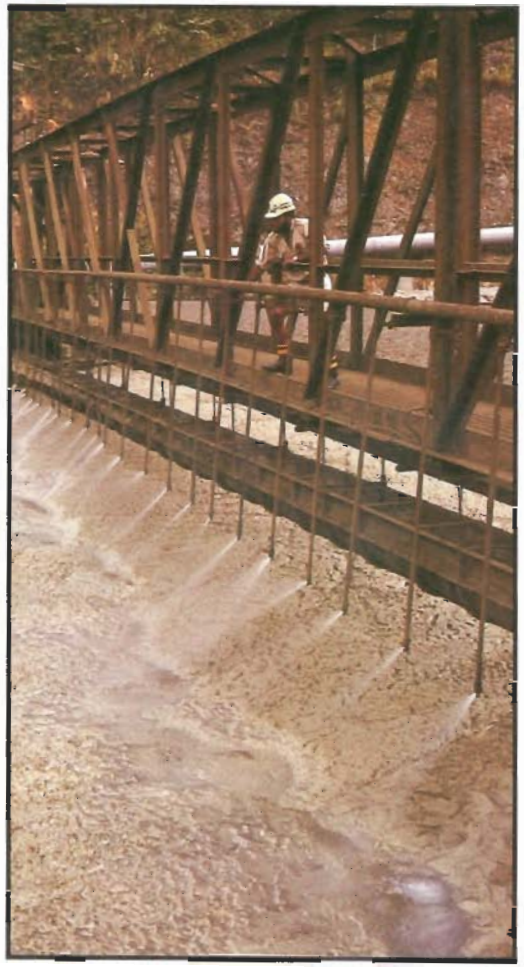


Concentrator complex.



Ball mills.





Copper concentrate.

Quality control laboratory.

Supplying customers

The concentrate produced at Panguna undergoes several more processes before it is suitable for shipping. First of these is thickening which occurs in the concentrator area and is the final stage before the concentrate is pumped in a 150 mm diameter steel pipeline across the Crown Prince Range to the BCL port at Anewa Bay.

At the port the concentrate's water content is reduced to approximately 8% by vacuum filtering and rotary kiln drying, ready for loading into ships from a 60,000 tonne storage area. The Anewa Bay port is the springboard for supply of copper concentrate to the Company's customers in world markets.

The first commercial shipment -- to a smelter in West Germany -- left in the ore carrier 'Anne Mildred Brovig' in April 1972. Since then regular shipments averaging 20,000 tonnes have been made to all customers.

Bougainville Copper Limited is a significant world exporter of copper concentrates and its profitability is closely related to the copper price as expressed in daily quotations on the London Metal Exchange.

Under its contracts Bougainville Copper receives ruling London metal prices for copper, gold and silver contained in the delivered concentrate, less refining and smelting charges and other negotiated deductions.

Loading copper concentrate for export.

Company people

One of the fundamental principles in the Bougainville operation has been that increasing and widening employment opportunities would be available to the local people of Papua New Guinea.

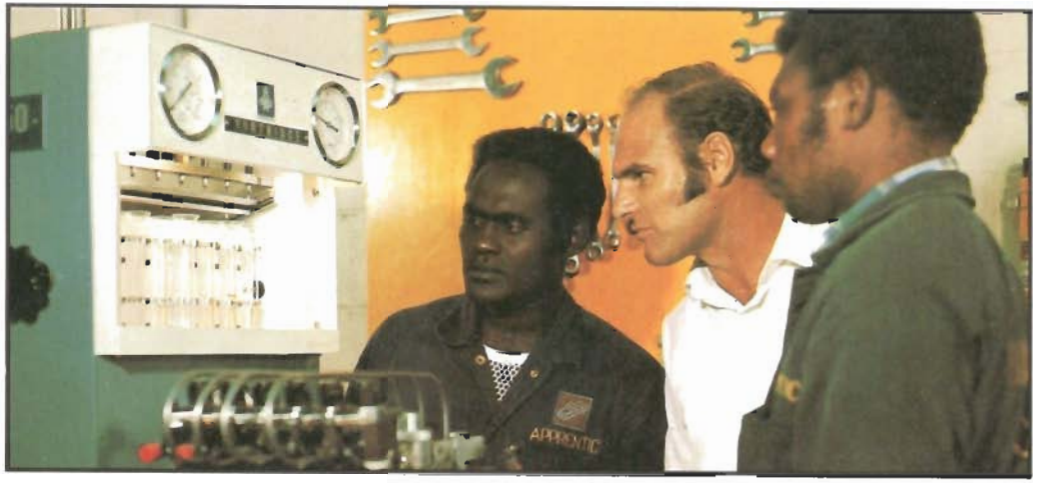
Accommodating, servicing, training and advancing opportunities for its workforce have been among Bougainville Copper's highest priorities. Throughout the phases of exploration, evaluation, construction and operations a consistent personnel policy aimed at blending necessary competence with a firm approach to localisation has been followed.

The success of such a program depends on co-operation and goodwill (such as the willingness of expatriate personnel to pass on skills, often to train themselves out of a job), on the aptitude and enthusiasm of national personnel for the project, on teamwork and good communication.

Many Papua New Guineans joining Bougainville Copper need to be trained. The Company foresaw this and has placed great emphasis on training, not only that necessary for operations but in social and allied fields, for expatriate as well as local people. It has trained many more personnel than required for its own particular needs.

Company training activity is broadly based. The first graduates from universities joined the Company at the end of 1972 and the Company now has national graduates in the diverse fields of geology, civil engineering, electrical engineering, law, accounting.

Operator training is an ongoing requirement to maintain a reserve of people with the necessary skills to control the complex plant and equipment. However, with all operator positions localised the main accent is on training in the trades and professional areas. A well equipped training college is conducted by the Company. This provides both practical and theoretical training for some 300 apprentices over a wide range of trades and administrative skills. None are formally bonded but most are expected to go on to responsible positions within the company.



Community services

Bougainville Copper provides a large range of services on Bougainville Island.

Services essential to the operation, such as roads, power and accommodation, also benefit the local economy. The port mine access road today is the nucleus of a road system that crosses the island, so assisting intra-island trade. Power from the Company's plant is made available to population centres. The town of Arawa, is an "open" town and a focal point for business enterprise.

Many other modern services were provided by the Papua New Guinea Government as a direct consequence of Bougainville Copper's presence. They include comprehensive telecommunications facilities, an upgraded airstrip, new schools and a 250 bed hospital.

At Panguna, Arawa and Loloho beach a wide variety of civic and recreational facilities have been provided by the Company. They have helped greatly in the progressive establishment of a competent multi-racial workforce. But it is the people themselves who shape the quality of life in Panguna and Arawa. Voluntary effort has played an important part in developing pride in community activities.

Outside its direct mining operations the Company is active in numerous areas. In addition to providing information services, continuous contact is maintained with villages and assistance and advice frequently rendered. A business advisory service assists local people in establishing small business, help is given in developing livestock and poultry operations and improving garden productivity. Considerable garden produce is purchased for consumption in the messes operated for single employees.

The Panguna Development Foundation, which holds Company shares in trust for Papua New Guinea residents, is an additional vehicle designed to promote community development. Its principal activities so far have been at Arawa and Panguna where new population centres have created business opportunities. Trading companies, established under the sponsorship of the Foundation, operate wholesale and retail outlets. These not only provide for the needs of the community but also are a means for Papua New Guinea investment in new business opportunities.

Recreational facilities

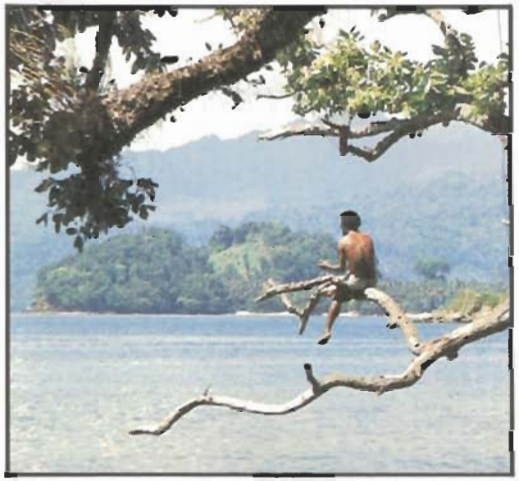
Bougainville's construction effort suggests that Company life may have been a case of all work and no play. This is not so. Recreation and provision of amentities were, and still are important in Company policy and with the majority of personnel.

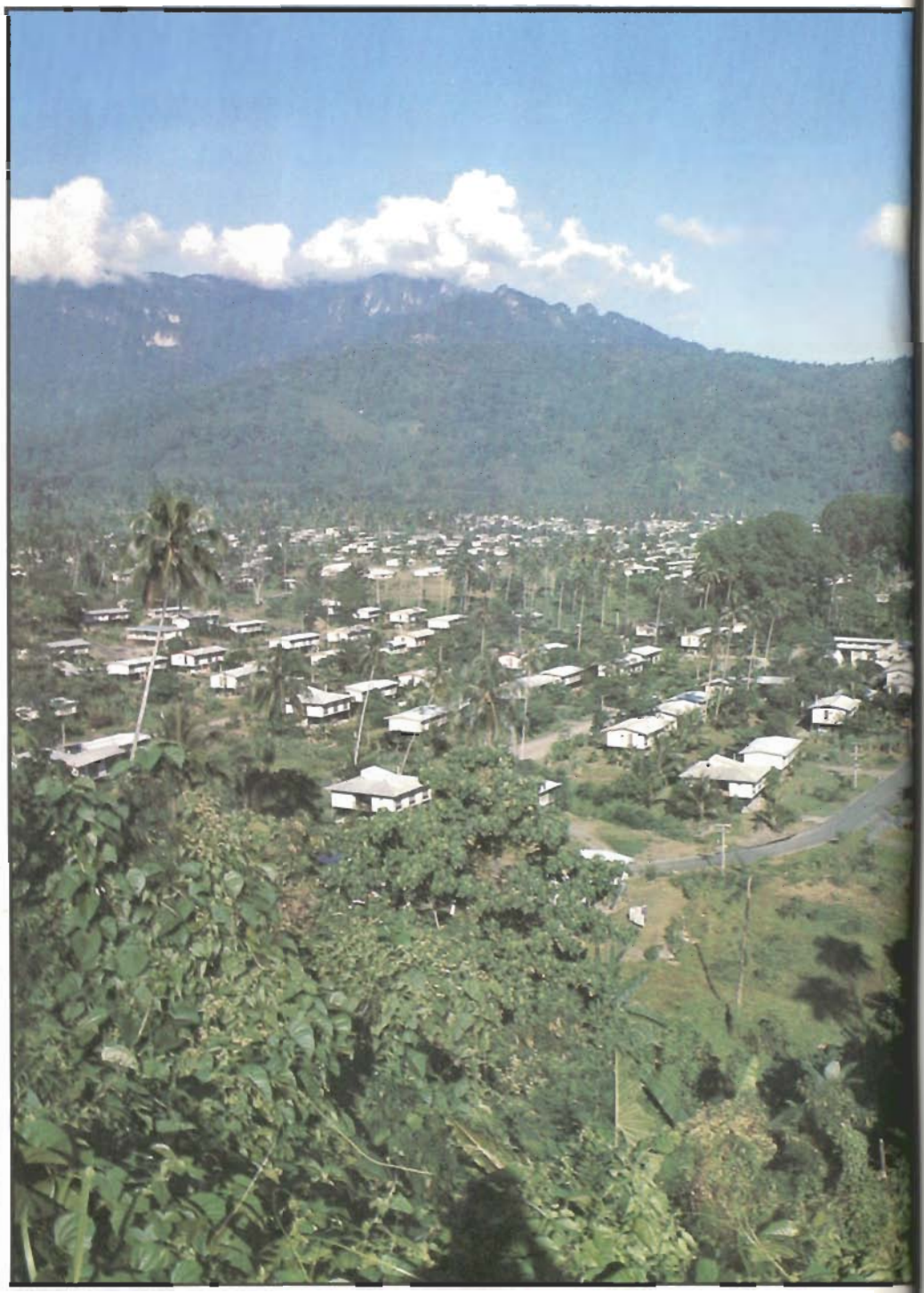
Recreational facilities cater for practically all people and all tastes. At Panguna football, cricket, tennis, basketball, squash and hockey are played competitively, there is a first class gymnasium for indoor sport and an Olympic-size swimming pool provides further opportunity for relaxation and fun as well as competitive swimming.

At Loloho Beach near the Anewa Bay portsite, one of the former construction camps has been developed into a recreational centre. The activities of fishing, boating and bathing are now supported by good picnic and beach facilities and the area is particularly popular at weekends.

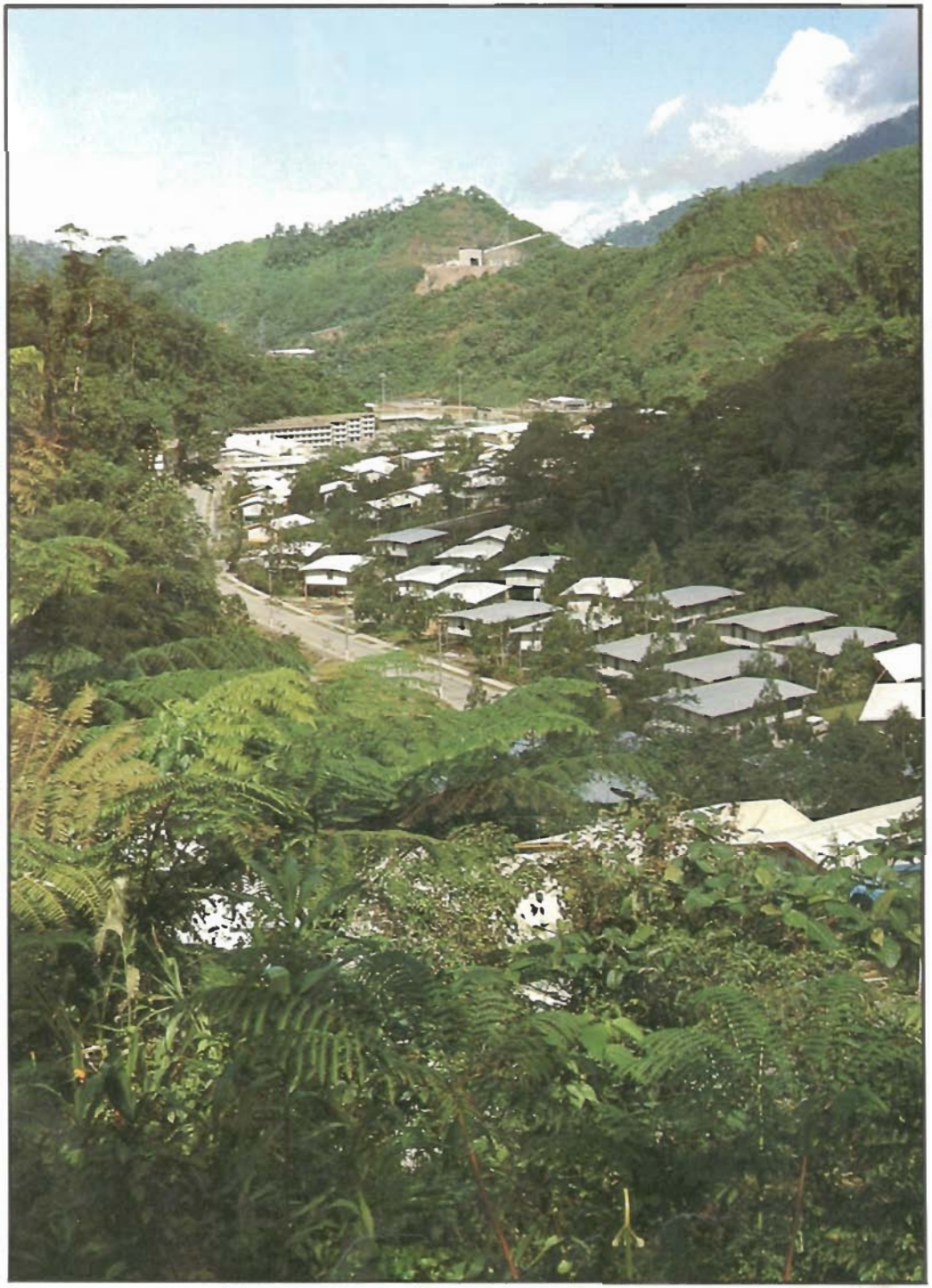
At Arawa a country club and golf course has been established, while yachtsmen have excellent club facilities at nearby Kieta.

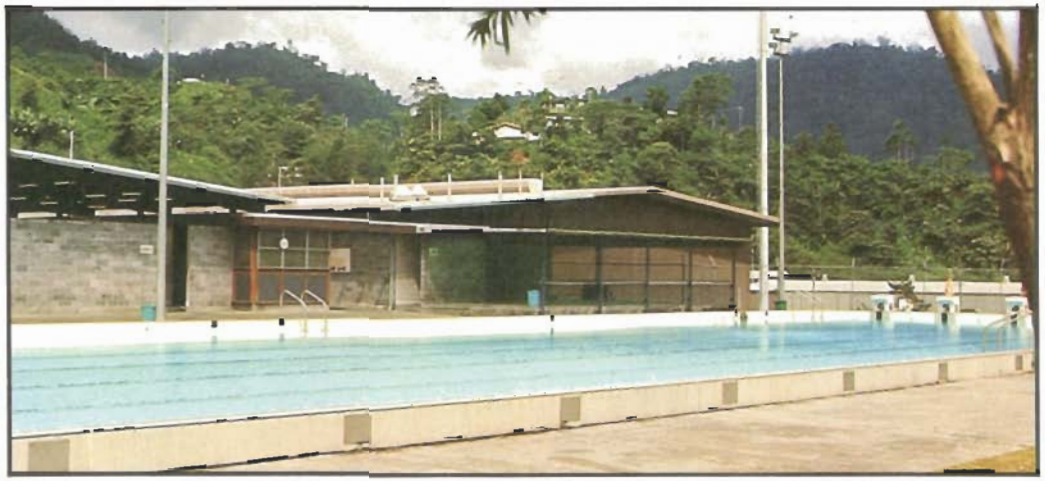
Voluntary committees and organisations play an important part in the development of community facilities and community life.

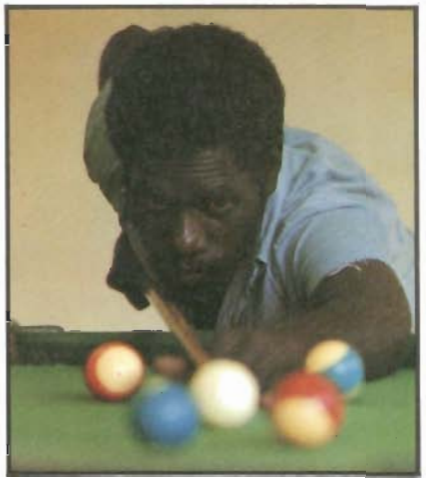




Arawa.







Panguna.

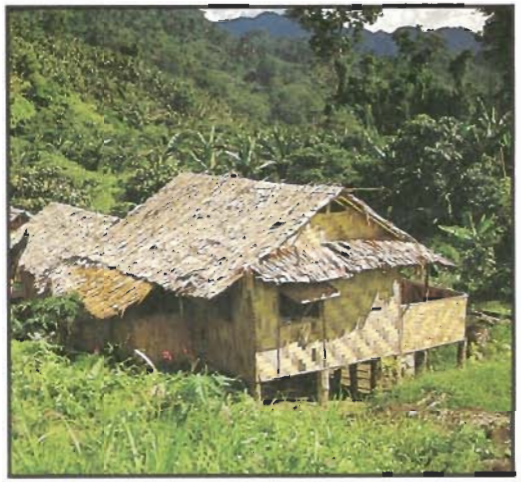
Ol Pipal

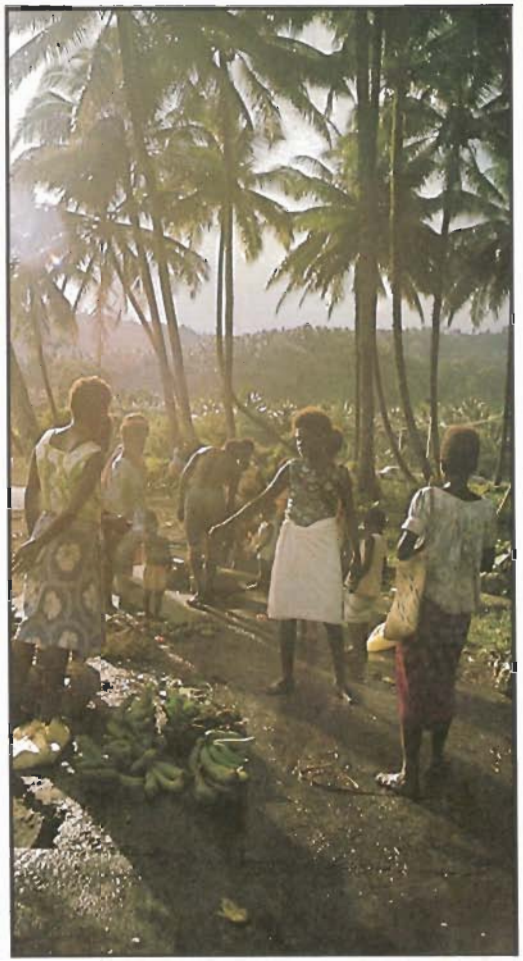
Although copper mining has become Papua New Guinea's largest industry it occupies only a small part of the land of Bougainville Island and is distant from the most populated areas. The traditional way of life continues for the majority of the 100,000 inhabitants.

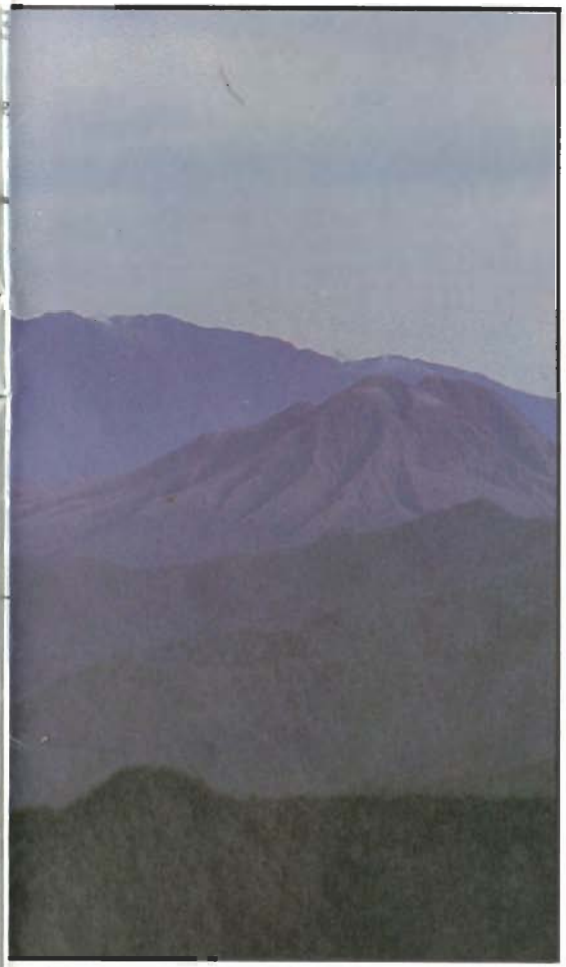
This is a life based on an agricultural subsistence village society but cash cropping is expanding and other forms of business enterprise are developing with the stimuli of a growth economy.

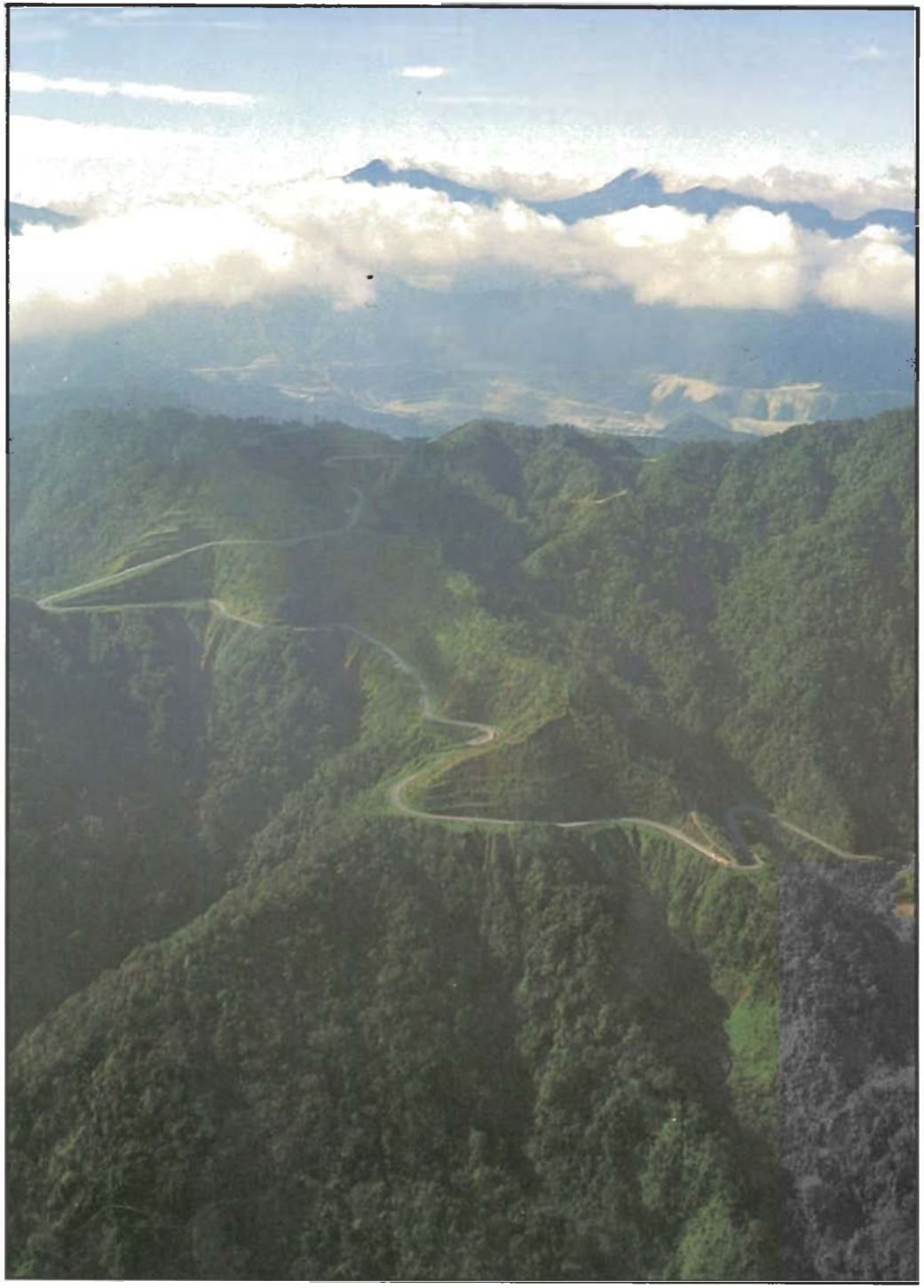
The people of Bougainville are proud of their heritage, their culture, their geography. They have seen and absorbed much change – the coming of Europeans at the end of the last century, the ugliness of war, the relative solitude that followed, and, lately, the impact of a giant mining operation. They are acutely aware of the future and strive to identify and shape their destiny. The Company always recognised that its undertaking would have some impact and that strains and uncertainties would occur. One of its prime responsibilities has been to minimise disruption and to eliminate misunderstandings.

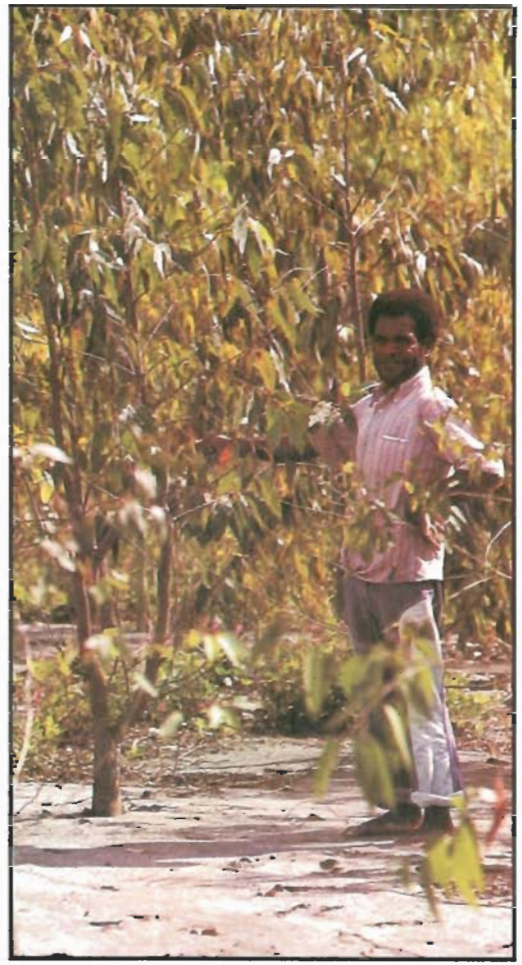
The Company's community policy has followed two main lines. It has sought to maximise the benefits available to local people and to ensure good communications at the village level. In this it does not promote western culture nor intrude into village life. It is a citizen of the area and it works at being a good citizen.











Reafforestation in tailings.

Uses of copper

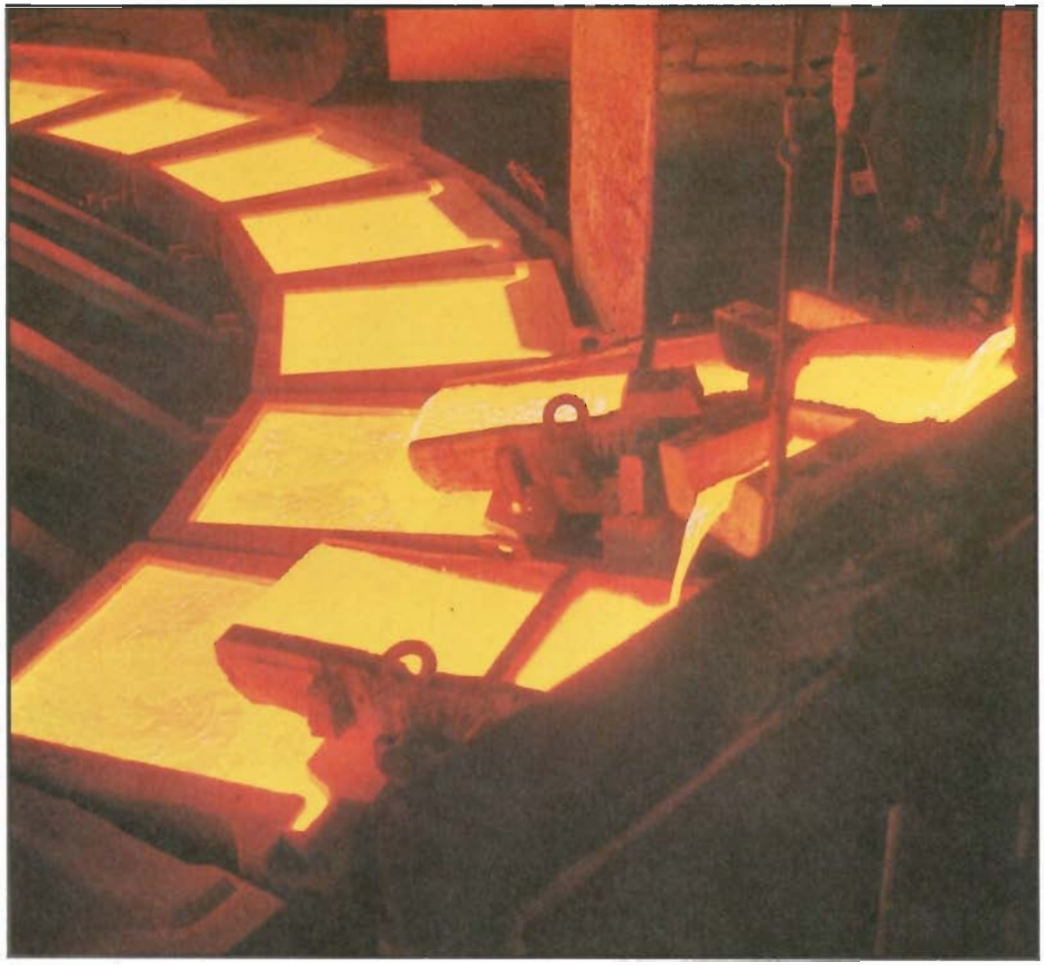
Since the beginning of history, copper has played a part in man's development.

Primitive man made crude weapons and tools from copper rocks and ancient civilisations like the Egyptians used this knowledge to hammer copper into sheets. From these sheets they moulded many products ranging from ornaments and coins to household utensils, tools and even water pipes. The discovery of bronze and brass as principal alloys of copper widened the usage of the metal. Although iron was being used as a basic metal, these alloys maintained a strong functional position and were used in roofing, plumbing and building.

The industrial revolution of the 19th century developed electricity as a means of power. With copper's unrivalled qualities of conductivity, durability and resistance to rust, its usage grew more sophisticated as it became widely used in the electrical field.

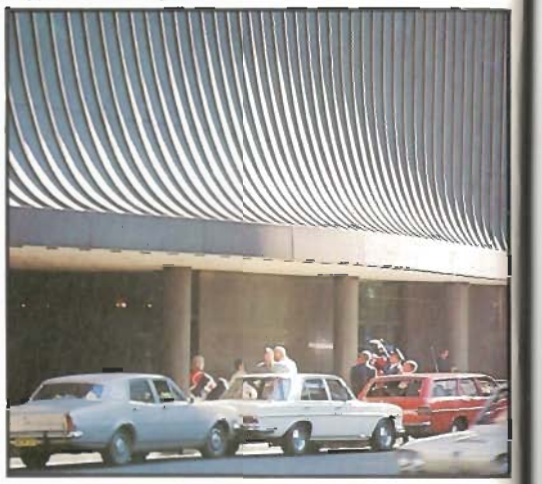
Television, telephones, computers and space programs make extensive use of copper, not to mention the thousands of everyday appliances used by modern society. Copper's proven versatility assures its future as a basic metal and as a vital element in advancing technology.

The world now uses some eight million tonnes of copper each year and with the discovery of new alloys and new technical applications, such as solar heating and desalination, consumption is expected to increase at the rate of about 5 per cent a year. This growing demand provides an incentive to develop new mines and improve extractive methods.

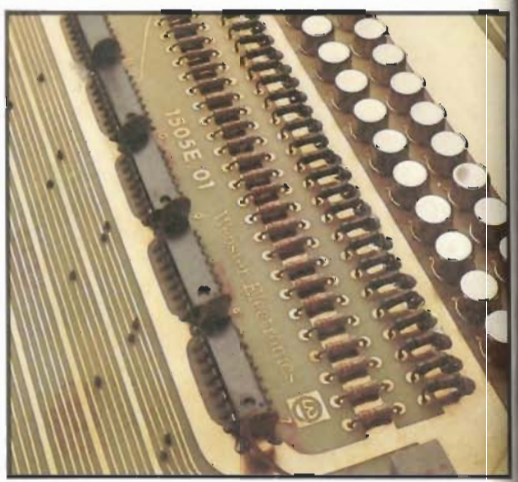


Pouring molten copper.

Copper in buildings.



Above right: Copper bathroom fittings.



Copper circuit.

Copper tubing.

Designed & produced by K. Middleton-Smith Pty. Ltd. Printed in Hong Kong by Toppan Printing Co. (H.K.) Ltd.

BOUGAINVILLE COPPER LIMITED