The Next Move

50 Years of the JKMRC

The Next Move: 50 Years of the JKMRC

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INTRODUCTION

Professor Neville Plint

I first heard about the JKMRC when I started working at Anglo American Platinum in 1996 as a Metallurgical Analyst focused on researching the fundamentals of froth flotation. It was described as 'ground breaking', 'innovative' and 'cutting edge', terms which inspired me as a young man at the start of my career in mining, to engage and collaborate with researchers at the JKMRC. This engagement continued throughout my career at Anglo American. As Director of the Institute which now includes the JKMRC, I believe those words equally describe the work of the JKMRC today as they did 25 years ago. Quite simply the JKMRC is unique because of the people and technologies it develops for the mining industry. The JKMRC continues to inspire and enable young researchers across mining, geology and minerals engineering to create change for a better world.

This book seeks to capture the last 50 years and looks ahead to the next 50. My thanks to all those who have contributed so much to the JKMRC over the years, and although we can't name everyone, I hope we have captured the ethos within these pages.

My thanks also to all those people who have given their time and support to this project.

Professor Neville Plint
Director, Sustainable Minerals Institute

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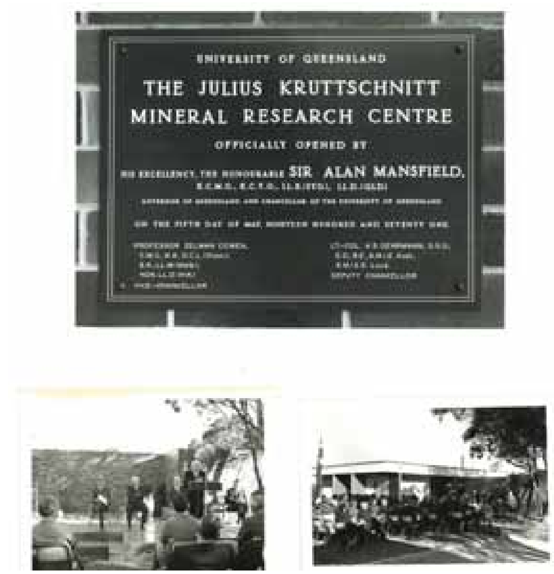


A scrapbook in the JKMRC library with a collecion of images from the opening of the JKMRC

Vintage photo of the preserved headframe at the JKMRC site

PREFACE

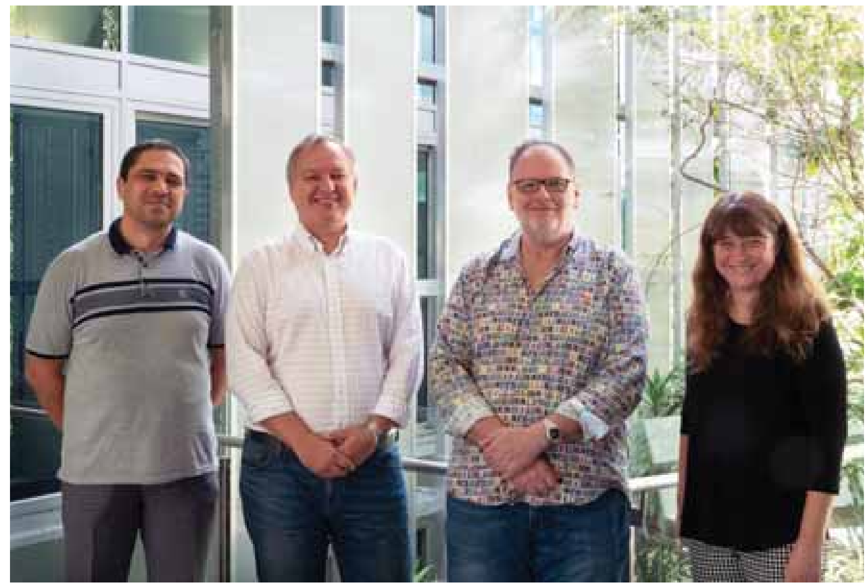
How was it possible for an idea which had its beginning in a tin shed in a Brisbane suburb to grow into one of the world's leading minerals and mining research centres? The answer lies in the story of the Julius Kruttschnitt Mineral Research Centre (JKMRC) at The University of Queensland. It is a story which has been almost 60 years in the making.

The title *The Next Move* is adapted from a much-used question by the founding leader of the JKMRC, Alban Lynch, to postgraduate students in the 1960s and 1970s. After reviewing their progress, he would usually ask 'What's your next move?'

After its establishment in the 60s, the story of the JKMRC is all about its next moves—working overseas, coal preparation research, blasting research, establishment of JKTech as a commercial entity, sale of software, instrumentation and consulting services worldwide, national and international research collaborations, a major role in establishing Co-operative Research Centres, mine-to-mill research, cave mining research and geometallurgy research. These were among the significant next moves for this unique research centre.

The JKMRC could have chosen to restrict its research to the modelling, simulation and control of comminution circuits after its early successes in the 60s. Indeed, 50 years later, the centre continues to work on these topics having produced advances never envisaged at the end of the 60s. But, instead of staying safely in its area of known expertise, Alban Lynch and his successors have continually identified new research and commercial opportunities and pursued them vigorously and successfully.

We hope this book captures something of the people of the centre, the technical achievements, the industry, and a far-sighted University that gave the JKMRC remarkable freedom to develop and pursue its goals and provided support when most needed.



Current JKMRC Group Leaders Associate Professor Mohsen Yahyaei, Associate Professor Marcin Ziemski, Professor Rick Valenta, Associate Professor Kym Runge

CHAPTER 1

PIONEERING & DARING

FROM HOLE IN THE GROUND TO GLOBAL BEACON

Many parables could be drawn from the evolution of the Julius Kruttschnitt Mineral Research Centre – transformed from a hole in the ground, to a seemingly ramshackle shed, to a globally respected beacon of knowledge.

The phrase 'from little things, big things grow' instantly springs to mind.

'The mouse that roared' or 'punching above its weight' are other appropriate descriptions for the humble facility, founded with a skeleton crew, but now recognised around the globe simply by the initials JKMRC.

In testament to the quick-thinking, adaptable nature of the visionary minds who led the JKMRC forward, a slogan such as 'there is more than one way to bake a cake' also has relevance.

Indeed, there are many ingredients to this story.

There is the story of the centre itself, a remarkable tale of a parcel of land which from ancient times until now, has captured more history than most could ever believe.

There is the story of the research which became the centre's hallmark, a relentless pattern of daring to be different, of painstaking dedication to discovering solutions to problems, ultimately characterised by immense, industry-changing breakthroughs.

Surrounding these tales is a larger account of a world that was advancing rapidly in many senses. Technology, politics, commercial pressures, an increasingly integrated global community, and an industry that never stood still are but a few factors deserving exploration.

The Finney's Hill mine site on which the JKMRC now stands, pictured in 1922

Early view of Indooroopilly from Finney's Hill

Indigenous fishing upstream in the Brisbane River in 1892

The stories of the people who have inhabited and influenced the JKMRC provide some of its most fascinating chapters. From the inimitable educators, to the gifted students, the supporters, agitators and one-of-a-kind identities, there is indeed enough to fill a book of its own.

The greatest story, however, is of the impact that the JKMRC would have; impact reaching well beyond the borders of the city of Brisbane, the state of Queensland, the shores of Australia.

In its 50th year of existence, 2020, the Julius Kruttschnitt Mineral Research Centre is acknowledged as vitally important to the world of mining.

Every step of the way; from identification, to extraction, to processing; from classroom, to laboratory, to the field; the JKMRC can lay claim to making a profound difference.

Meld all of these smaller stories into one and you have a chronicle rich with priceless detail, admirable adventures, and insight to the amazing capacity of the human mind and its quest for greater knowledge.

INDOOROOPILLY'S INDIGENOUS HISTORY

The land on which the JKMRC now stands has a fascinating history, including when the Indigenous Turrbal and Jagera people occupied the Brisbane region.

Even among those native to Brisbane in modern times, few realise the Brisbane River was known as Mairwar prior to European settlement.

Mairwar is derived from one of the many Indigenous languages of the period, Dungidau, and signifies a place of the uniquely Australian creature, the platypus.

This is meaningful in the context of the JKMRC, because the centre is positioned less than 500 metres from the banks of the Brisbane River at Indooroopilly, close to a confluence with what is now known as Witton Creek.

Witton Creek itself passes narrowly behind the JKMRC, roughly 100 metres to the south-east.

Historian Dr Ray Kerkhove, a University of Queensland alumnus, contends that the junction of Mairwar (Brisbane River) and Witton Creek was a fertile and popular spot for fishing and prawning among the Indigenous inhabitants.

The presence of sand and sediment deposits on the southern side of Mairwar, where the railway bridge now crosses from Chelmer to Indooroopilly, also suggest this area was likely used for swimming and relaxation. Indeed, photographic evidence displays people flocking to the area to swim as late as the 1930s, though it is seldom used this way now.

In his book *Aboriginal Campsites of Greater Brisbane*, Dr Kerkhove speculates that the entire region held significance to Indigenous occupants pre-colonisation, quite possibly for rain-making rituals.

This belief is strengthened by the flora and geography of the area, as vine forests, lagoons and gullies distinguished it from neighbouring areas, suggesting a more tropical clime.

Indooroopilly, the modern suburb, derives its name from an Indigenous phrase meaning either 'gully of the leeches' or 'gully of running water'.

It is fitting in a book of this nature to consider the geological attributes inherent in the region where the JKMRC now stands – and how these contributed to a mine being constructed on the site.

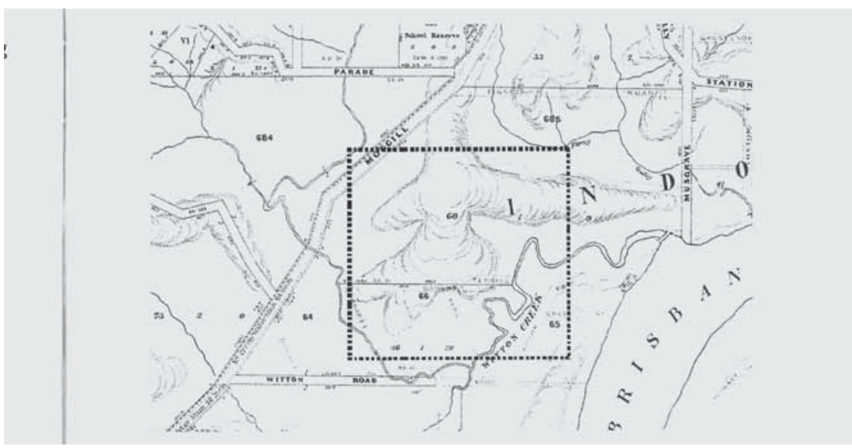
Just two kilometres to the north-west of the JKMRC's current site is Mount Coot-Tha, the highest point within Brisbane's urban district. The name Mount Coot-Tha translates to 'Honey Mountain' and signifies the Indigenous practice of collecting honey from trees in the area.

Readers can correctly assume that to be positioned so close to both a major mountain and major river meant drastic topographical change in the local landscape – and underlying reasons for the sharp gradient.

Residents flock to swim at Chelmer 'beach' on the southern side of the Brisbane River in the 1930s

Rock art installation at Mount Coot-tha, signifying the area's Indigenous history

View of Indooroopilly before widespread development, looking from Mount Coot-tha



Local map of Finney's Hill where the JKMRC is now situated

Even now, aside from Witton Creek, no fewer than four other creeks cascade down from Mount Coot-Tha to the Brisbane River in a relatively small stretch of just over six kilometres, though many are hidden by modern drainage and contouring.

The JKMRC is positioned adjacent to an almost horseshoe-shaped geological formation of intrusive rhyolite, perched high above the nearby river. Closely related to granite, rhyolite is what occurs when a hot granitic magma solidifies very quickly at or near the earth's surface, making the grains so fine that they can't be seen with the naked eye.

When magma rises, it often brings with it deposits of precious metals and minerals – a fact that becomes relevant as you read further.

Another detail most modern Brisbane residents won't be aware of, is that Indooroopilly sits in close proximity to what has been termed the 'Kenmore Fault', though it is not an active or aggressive fault line.

While the history of the JKMRC is justly celebrated as being 50 years old, the Indigenous history of the area comprises tens-of-thousands of years more, and the geography itself spans tens-of-millions of years.

EUROPEAN SETTLEMENT

Despite exploration of the area in previous decades – when Europeans referred to the district as Witton – it wasn't until 1860 that Indooroopilly was permanently settled by Europeans.

It rapidly changed appearance.

The completion of the Royal Albert Bridge linked the area north of the Brisbane River to the Ipswich railway system and the coal fields to the south-west, leading the Indooroopilly area to flourish.

When the great flood of 1893 washed away a 25-metre section of the railway bridge, and it was subsequently rebuilt, the tempestuous nature of Queensland's weather and the stubborn nature of the settlers were both placed on display.

In 1918 ore bearing silver and lead (more specifically argentiferous cerussite and galena) was discovered in a garden rockery on what was known as Finney's Hill, 60 metres above sea level, the precise location where the JKMRC now exists.

At first, the discovery was kept "a close secret" by landowner Mr G J Olsen, according to the insightful book *Silver Hill,* penned by Ken Grubb.

Yet, during the following 11 years, over 227,000 ounces of silver and nearly 1,800 tonnes of lead were extracted from the site.

It's important to consider the timing. In 1918 the First World War was ending and an appetite for ore was prominent, as was the hunger for new and profitable economic ventures.

In 1929 when the mine ceased to operate, the world's financial markets had collapsed, marking the onset of the Great Depression.

Yet, even before the Great Depression, the mine had undergone tumult and closed temporarily in 1926 due to numerous compounding factors.

Firstly, there was the unusually frequent rainfall in 1925, when 83 wet days were recorded (compared to an average 14 days in preceding years), leading to work stoppages, subsidence and difficulties handling the ore.

A labour strike which then stopped production for three months, a drop in global metal prices, increasing costs in extraction, and depletion of the higher-grade deposits all combined to thwart the mine as a viable concern.

Although the mine briefly reopened in 1927 and 1928 under a change of ownership, its lack of profitability would again become its downfall.

As is often said, many of the greatest lessons can be gleaned from times of failure.

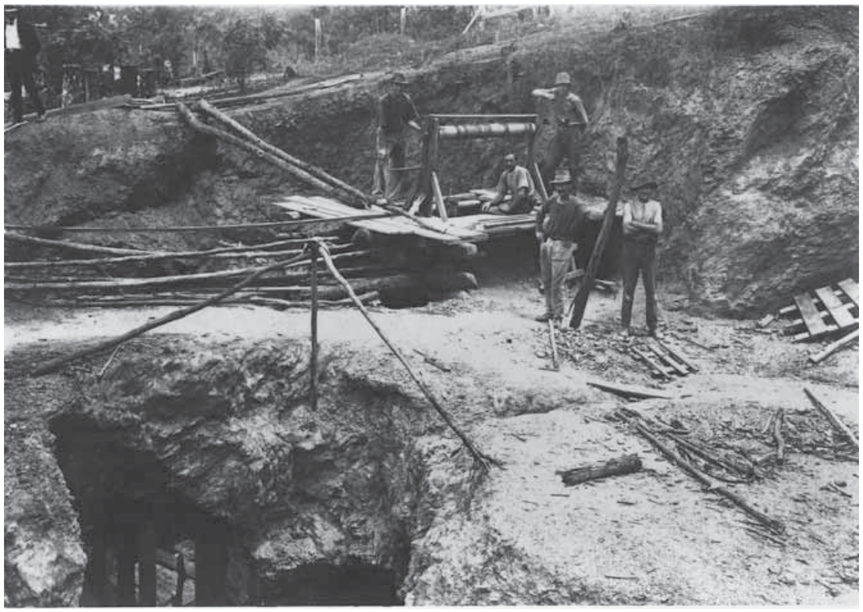
While the life of the Finney's Hill mine was relatively short-lived, it sparked general interest in minerals and metals exploration in the Brisbane region.

Ore discovery on the land of GJ Olsen

Early extraction of Finney's Hill by horse and cart

A rich gold deposit was later found in the northern footings of the nearby Walter Taylor Bridge at Indooroopilly.

More lastingly, the obstacles encountered by the original mine site would be forever present in the minds of those pioneering researchers who later occupied the JKMRC; lessons from the past and a presiding motivation to pursue efficiency and ingenuity.



The rudimentary beginnings of Finney's Hill mine site

FROM ABANDONED & UNWANTED TO INVALUABLE ASSET

For an astonishing 21 years the old mine site on Finney's Hill sat unwanted and dormant.

The structures of the mine had rotted and rusted, shafts and tunnels had collapsed and the facility was susceptible to flooding.

Ownership of the roughly 20 acres of land had passed over to the Brisbane City Council and the abandoned area was treated with intrigue and suspicion in some quarters, particularly by new arrivals to the suburb.

To this day, those who do not know the history of the precinct understandably wonder how it is that a mine site exists in close proximity to the city's central business district. The peculiar location of the JKMRC, a detour off popular throughfares, up a winding hillside road, cloaked behind regenerated bushland, has only added to the sense of mystique.

Yet in 1951, the visionary Professor Frank White saw past misconceptions and apprehension to play an influential role in The University of Queensland purchasing the unused facility.

It was to signify the start of another, wildly different, chapter for this patch of earth.

Named the founding professor of UQ's Mining Department in 1949, White had by then already enjoyed a storied career that included establishing the Department of Mines in Fiji, rehabilitating tin mines in Malaysia, and qualifying as a magistrate in mining law, among many other achievements.

Considered a father figure by many University students, Professor White was a persuasive and ambitious individual who boasted strong support from industry stakeholders and held a genuine passion for research.

He had two very important attributes which established a platform for what would later become the Julius Kruttschnitt Mineral Research Centre – an unrelenting drive and a capacity to source means of funding.

So, it came to be under his watch that mining undergraduates utilised the Finney's Hill mine as a laboratory for experimental work.

Notations in a Queensland Government journal of the time declared the UQ Department of Mining and Metallurgical Engineering would maintain and operate the "unique facility" for "related subjects which cannot be covered fully in the lecture room or in normal laboratories".

A sign of the times was that a report, compiled when the mine changed hands, described the site as "12 chains from the Brisbane River" and "52 chains south of west from Indooroopilly Railway Station". A 'chain' is equivalent to a figure fractionally longer than today's metric measure of 20 metres.

It was towards the end of the 1950s that several important occurrences happened in quick succession.

In 1959 White came into close proximity with Alban Lynch and, around the same time, the Australian Mineral Industries Research Association (AMIRA) was established.

Both of these were to have positive and fateful consequences.

Professor Frank TM White

Alban Lynch at the outset of his career

THE LYNCH EFFECT

Timing, as they say, is everything.

In the years after the mine was handed over to The University of Queensland to utilise for the purposes of teaching and experimental research, a young Alban Lynch was on the lookout for a new challenge. He headed to Brisbane.

Although born in Queensland's capital, Lynch had spent no substantial length of time in the city, instead enjoying the formative years of his working career in Sydney, then outback Broken Hill, more than 900km inland.

The motivated young man was described as coming from a family of teachers, but possessing the mind of a scientist.

He studied chemical engineering at Sydney Technical College (later the University of New South Wales) while working in the paint industry.

However, as happens with many young people, his next steps in life were dictated by a matter of financial necessity.

Houses in Broken Hill could be bought for as little as £100 in the early 1950s, while the Sydney housing market was notoriously difficult to break into.

When Lynch and fiancée Barbara headed west to the bush outpost, Broken Hill was somewhat of a flourishing oasis.

There were tree-lined parks, sporting fields, social clubs, hotels and one of the highest rates of car ownership in Australia.

A visit from a young Queen Elizabeth and Duke of Edinburgh only added to the sense of being amid the zeitgeist.

Mineral deposits had established Broken Hill as a prosperous place to reside and, accordingly, Lynch found employment as a metallurgist with the Zinc Corporation.

It was in Broken Hill that he learned the basics of mineral processing and developed an aptitude and interest for research into grinding.

Broken Hill is a township which features in the backstory to several of the JKMRC's leading figures, including current Group Leader of Separation, Kym Runge.

While working for the Zinc Corporation Lynch developed a mathematical model of breakage in a rod mill and demonstrated the modelling could pave the way to increased productivity.

Lynch's work was insightful enough to earn him a Master's degree from the University of New South Wales.

In 1958, with an appetite for practical research and his sights set on obtaining a PhD, Lynch was lured north to UQ.

Having already had a taste of working in the field, Lynch spurned the traditional on-campus learning environment, instead preferring to base himself in a makeshift shed at the Indooroopilly mine site, some six kilometres away from UQ's main campus at St Lucia.

Lynch wanted more practical surrounds than an office and a desk, thus forming the genesis of his legend within JKMRC history.

At that precise point in his life, Lynch was investigating the leaching of ore from a uranium deposit outside of Mount Isa.

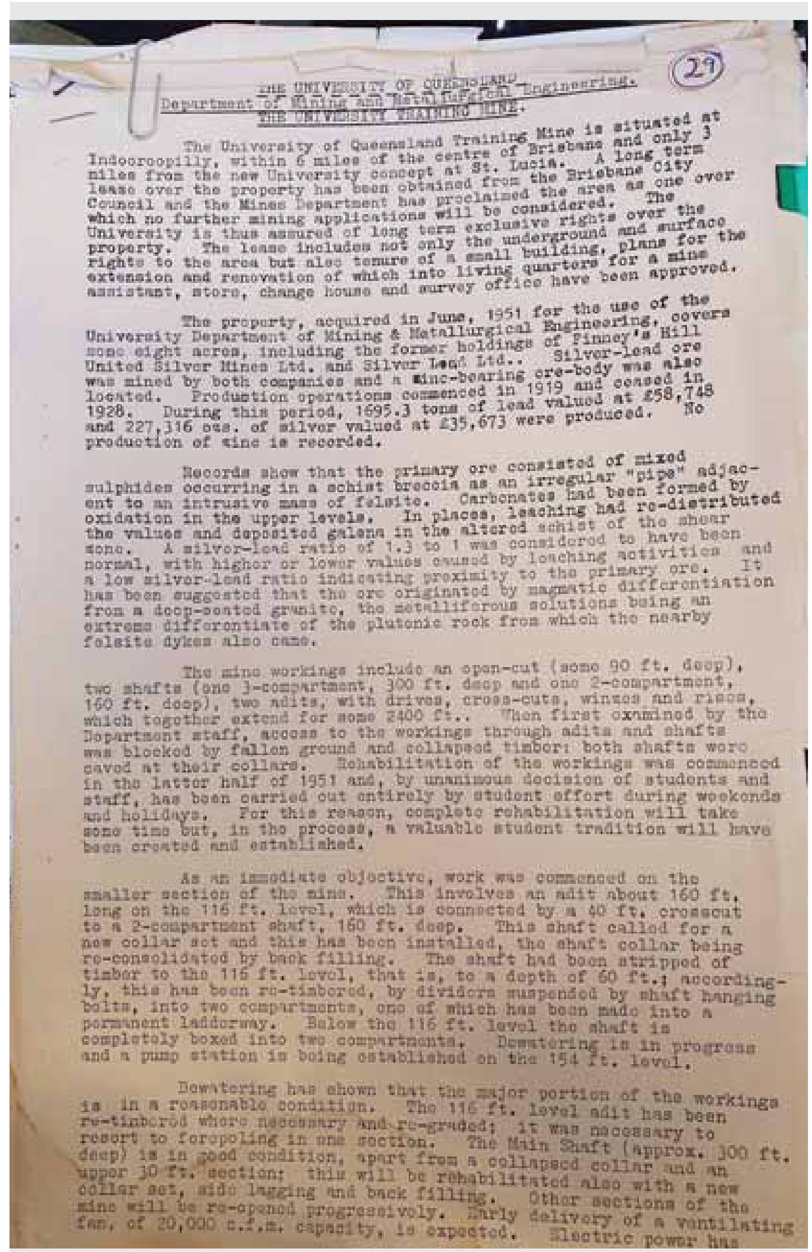
Though Lynch's first line of research was unsuccessful, Professor White was a strong supporter. He had a high regard for Lynch and his links with industry.

As Lynch ascended from a PhD hopeful to a research group leader after several subsequent projects, he built a formidable reputation.

Students by-and-large remember Lynch as tough but fair.

He would never consider buying an air conditioner – so they worked with sweat running down their backs. Lynch said it made them stronger!

He started work at 7am and finished at 7pm and expected others to do the same. Although it was demanding, others followed his example. Lynch was an inspiring and effective leader, a fact pointed to by many glowing testimonies.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THE UNIVERSITY OF QUEENSLAND
Department of Mining and Metallurgical Engineering.
THE UNIVERSITY TRAINING MINE.

The University of Queensland Training Mine is situated at Indooroopilly, within 6 miles of the centre of Brisbane and only 3 miles from the new University concept at St. Lucia. A long term lease over the property has been obtained from the Brisbane City Council and the Mines Department has proclaimed the area as one over which no further mining applications will be considered. The University is thus assured of long term exclusive rights over the property. The lease includes not only the underground and surface rights to the area but also tenure of a small building, plans for the extension and renovation of which into living quarters for a mine assistant, store, change house and survey office have been approved.

The property, acquired in June, 1951 for the use of the University Department of Mining & Metallurgical Engineering, covers some eight acres, including the former holdings of Finney's Hill United Silver Mines Ltd. and Silver Lead Ltd.. Silver-lead ore was mined by both companies and a zinc-bearing ore-body was also located. Production operations commenced in 1919 and ceased in 1928. During this period, 1695.3 tons of lead valued at £58,748 and 227,316 ozs. of silver valued at £35,673 were produced. No production of zinc is recorded.

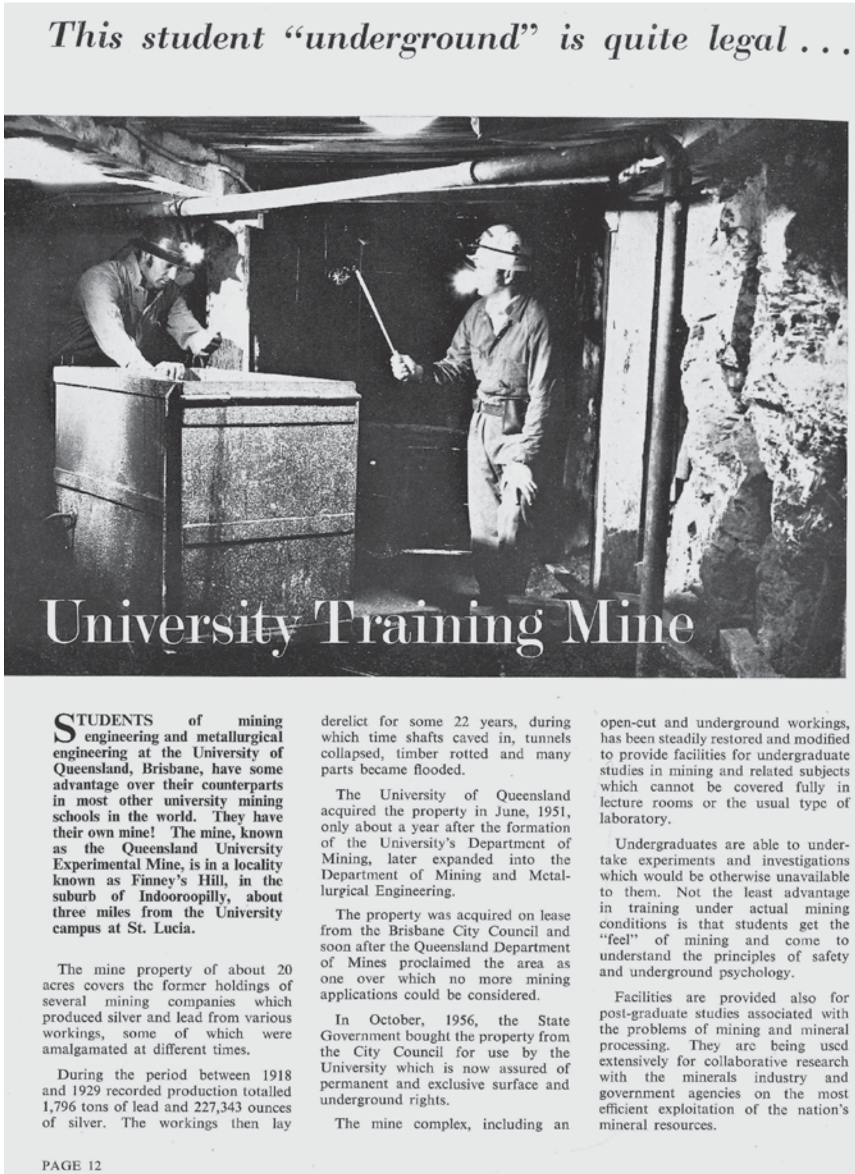
Records show that the primary ore consisted of mixed sulphides occurring in a schist breccia as an irregular "pipe" adjac-
ent to an intrusive mass of felsite. Carbonates had been formed by oxidation in the upper levels. In places, leaching had re-distributed the values and deposited galena in the altered schist of the shear zone. A silver-lead ratio of 1.3 to 1 was considered to have been normal, with higher or lower values caused by leaching activities and a low silver-lead ratio indicating proximity to the primary ore. It has been suggested that the ore originated by magmatic differentiation from a deep-seated granite, the metalliferous solutions being an extreme differentiate of the plutonic rock from which the nearby felsite dykes also came.

The mine workings include an open-cut (some 90 ft. deep), two shafts (one 3-compartment, 300 ft. deep and one 2-compartment, 160 ft. deep), two adits, with drives, cross-cuts, winzes and rises, which together extend for some 2400 ft.. When first examined by the Department staff, access to the workings through adits and shafts was blocked by fallen ground and collapsed timber: both shafts were caved at their collars. Rehabilitation of the workings was commenced in the latter half of 1951 and, by unanimous decision of students and staff, has been carried out entirely by student effort during weekends and holidays. For this reason, complete rehabilitation will take some time but, in the process, a valuable student tradition will have been created and established.

As an immediate objective, work was commenced on the smaller section of the mine. This involves an adit about 160 ft. long on the 116 ft. level, which is connected by a 40 ft. crosscut to a 2-compartment shaft, 160 ft. deep. This shaft called for a new collar set and this has been installed, the shaft collar being re-consolidated by back filling. The shaft had been stripped of timber to the 116 ft. level, that is, to a depth of 60 ft.; accordingly, this has been re-timbered, by dividers suspended by shaft hanging bolts, into two compartments, one of which has been made into a permanent ladderway. Below the 116 ft. level the shaft is completely boxed into two compartments. Dewatering is in progress and a pump station is being established on the 154 ft. level.

Dewatering has shown that the major portion of the workings is in a reasonable condition. The 116 ft. level adit has been re-timbered where necessary and re-graded; it was necessary to resort to forepoling in one section. The Main Shaft (approx. 300 ft. deep) is in good condition, apart from a collapsed collar and an upper 30 ft. section: this will be rehabilitated also with a new collar set, side lagging and back filling. Other sections of the mine will be re-opened progressively. Early delivery of a ventilating fan, of 20,000 c.f.m. capacity, is expected. Electric power has

Report of the 1951 acquisition of the mine site by The University of Queensland



This student "underground" is quite legal . . .

University Training Mine

STUDENTS of mining engineering and metallurgical engineering at the University of Queensland, Brisbane, have some advantage over their counterparts in most other university mining schools in the world. They have their own mine! The mine, known as the Queensland University Experimental Mine, is in a locality known as Finney's Hill, in the suburb of Indooroopilly, about three miles from the University campus at St. Lucia.

The mine property of about 20 acres covers the former holdings of several mining companies which produced silver and lead from various workings, some of which were amalgamated at different times.

During the period between 1918 and 1929 recorded production totalled 1,796 tons of lead and 227,343 ounces of silver. The workings then lay derelict for some 22 years, during which time shafts caved in, tunnels collapsed, timber rotted and many parts became flooded.

The University of Queensland acquired the property in June, 1951, only about a year after the formation of the University's Department of Mining, later expanded into the Department of Mining and Metallurgical Engineering.

The property was acquired on lease from the Brisbane City Council and soon after the Queensland Department of Mines proclaimed the area as one over which no more mining applications could be considered.

In October, 1956, the State Government bought the property from the City Council for use by the University which is now assured of permanent and exclusive surface and underground rights.

The mine complex, including an open-cut and underground workings, has been steadily restored and modified to provide facilities for undergraduate studies in mining and related subjects which cannot be covered fully in lecture rooms or the usual type of laboratory.

Undergraduates are able to undertake experiments and investigations which would be otherwise unavailable to them. Not the least advantage in training under actual mining conditions is that students get the "feel" of mining and come to understand the principles of safety and underground psychology.

Facilities are provided also for post-graduate studies associated with the problems of mining and mineral processing. They are being used extensively for collaborative research with the minerals industry and government agencies on the most efficient exploitation of the nation's mineral resources.

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Article from National Development Quarterly about the training mine

"I worshipped him. He was a wonderful example of what a human being was and should be," said metallurgical engineering graduate Cameron McKenzie.

"He motivated people by example. If you wanted to see him in his office he would always see you. He was an inspiring man.'

At the opening of the JKMRC's Stage 3 building in 1993, Lynch offered three secrets to his recipe for success over many years at the helm. They were:

- Rely on the energy and intelligence of the postgraduate students
- Work closely with industry
- Only attack the big problems

THE SHED WHERE IT ALL STARTED

"Invigorating but uncomfortable."

That was how Lynch described the sweaty confines of a corrugated iron shed which later gave birth to some of history's most important breakthroughs in global mineral processing.

Measuring 18m x 15m and situated alongside the previously abandoned silver mine, near to verdant hills, the shack was a favourite haunt for all manner of creatures.

"There was little head room…exposed steel beams supported the roof at shoulder level," recalled early PhD student Don McKee, later director of the JKMRC.

"The toilet outside the shed resembled an old-style outhouse and was an attractive home for snakes."

WHAT'S IN A NAME?

Described as a "quietly-spoken American from New Orleans", Julius Kruttschnitt arrived in Australia at the age of 45, already boasting more than 20 years' worth of experience in the mining sector.

He was clearly a man skilled in adaptation, as his life had already taken him from Louisiana to California, to Connecticut, next to Arizona, then to Mexico, before returning to Arizona again.

Kruttschnitt was beckoned to Australia by his employer American Smelting and Refining Company (ASARCO) and made general manager of Mount Isa Mines – an interest that was on the verge of bankruptcy.

"The company soon learnt it had bought a burden rather than a prize," Don McKee said.

"Kruttschnitt discovered that conditions at the mine were worse than he could have imagined.

"The two shafts of the mine – one for hauling ore to the surface, and one for carrying men and supplies to the mine – were both flooded.

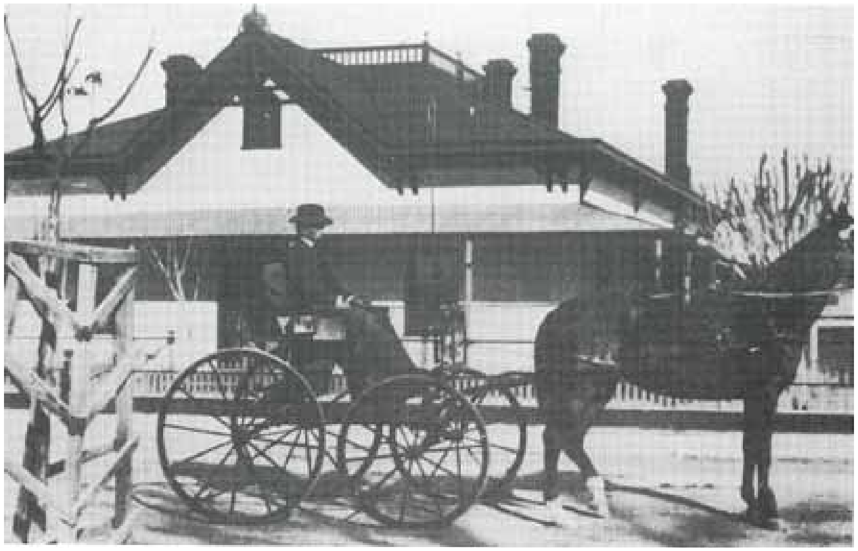
"The company did not have pumps or power to control the flooding."

Despite the obvious adversity, the first ore was put through the plant six months later.

More obstacles were to come as the mill and smelter failed. Kruttschnitt needed to immediately double the capacity of the smelter plant and add another blast furnace.

A series of increasingly depressing telegrams to ASARCO head office revealed a series of travails, from the fineness of the minerals to constant cost pressures.

Julius Kruttschnitt as General Manager of Mount Isa Mines



The Kruttschnitt family home in Arizona

Mount Isa railway station in 1933

In reply, telegrams from head office became more terse as Kruttschnitt pressed his demands for more money – although his reputation counted in his favour and the company risked far more than they first intended to keep the operation going.

It took seven years for Kruttschnitt's doggedness to pay off – but pay off it did. In 1936-37 Mount Isa Mines recorded its first profit and blossomed into one of Australia's greatest mines.

The mine's ongoing success – and arguably the longevity of one of Queensland's most iconic cities – was a direct result of Julius Kruttschnitt's dogged and inspired leadership in desperate conditions.

Apart from his management of money and personnel, his ability to tap into the ingenuity of Australian engineers and metallurgist to solve pervading obstacles for mining in a remote location was a key attribute.

Kruttschnitt held multiple positions of importance outside Mount Isa Mines, among them two stints as president of the Australasian Institute of Mining and Metallurgy (AusIMM), and a 14-year tenure as president of the Queensland Chamber of Mines.

Critical to the narrative of this book, he was also a central figure in convincing The University of Queensland to offer a degree in mining engineering in 1950, after UQ's Mining Department had been established the year before.

Up to that point, Queensland as a state had by-and-large been a latecomer to University-based education concerning minerals.

As an aside, the Julius Kruttschnitt after which the JKMRC is named was actually born Julius Kruttschnitt II. His father, also Julius, had been a railway executive of note in the USA.

THE LETTER

The Australian Mineral Industries Research Association (AMIRA) was established in 1959 to "facilitate the technological advancement of its members in the mineral, coal, petroleum and associated industries" and shaped as a promising source of ongoing funding.

Thus, a new era for UQ began in 1961 with a letter sent from Professor Frank White to Beryl Jacka, who acted as AMIRA secretary.

The letter, seeking funding, was accompanied by a proposal from Alban Lynch for a three-year project titled 'The Development of a System for the Automatic Control of Ore Grinding Circuits'.

Professor White enthused about "A project which we consider could well prove to be the most important and, probably, the most rewarding line in the whole field of metallurgical and mineral dressing research".

Little did White realise how prophetic that statement was to become.

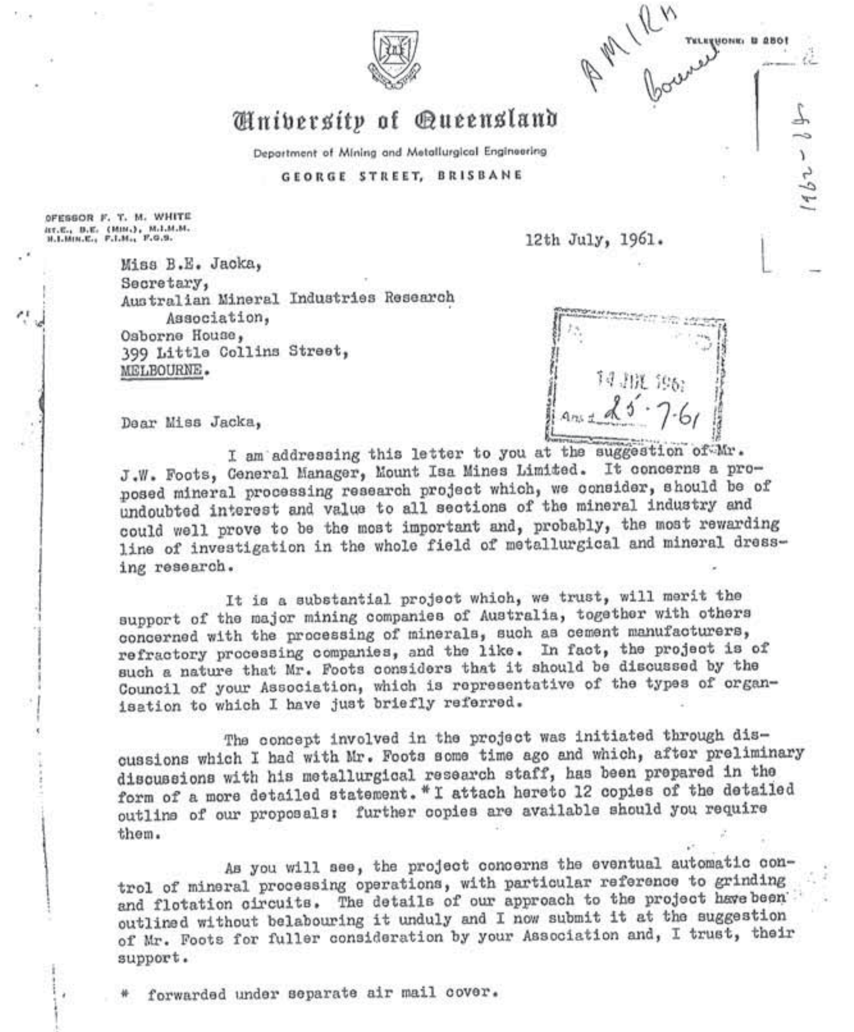
Quite significant was the fact the proposal was endorsed by Sir James Foots, general manager of Mount Isa Mines.

"As you will see, the project concerns the eventual automatic control of mineral processing operations, with particular reference to grinding and flotation circuits," Sir Foots wrote.

Alban Lynch's past achievements and lines of research with Zinc Corporation were highlighted in the proposal, specifically his ability to lift production by 15 per cent. This accomplishment was undoubtedly viewed as favourable by the funding allocators.

Although the initial proposal to AMIRA was described as extremely ambitious in some quarters – and not all aspects were supported – it was the leap of faith that was needed to propel things forward.

Funding was granted, beginning in 1962, for three years at £3000 per annum.



University of Queensland
Department of Mining and Metallurgical Engineering
GEORGE STREET, BRISBANE

TELEPHONE: B 2801

OFESSOR F. T. M. WHITE
RT.E., B.E. (MIN.), M.I.M.M.
M.I.MIN.E., F.I.M., F.G.S.

12th July, 1961.

Miss B.E. Jacka,
Secretary,
Australian Mineral Industries Research
Association,
Osborne House,
399 Little Collins Street,
MELBOURNE.

Dear Miss Jacka,

I am addressing this letter to you at the suggestion of Mr. J.W. Foots, General Manager, Mount Isa Mines Limited. It concerns a proposed mineral processing research project which, we consider, should be of undoubted interest and value to all sections of the mineral industry and could well prove to be the most important and, probably, the most rewarding line of investigation in the whole field of metallurgical and mineral dressing research.

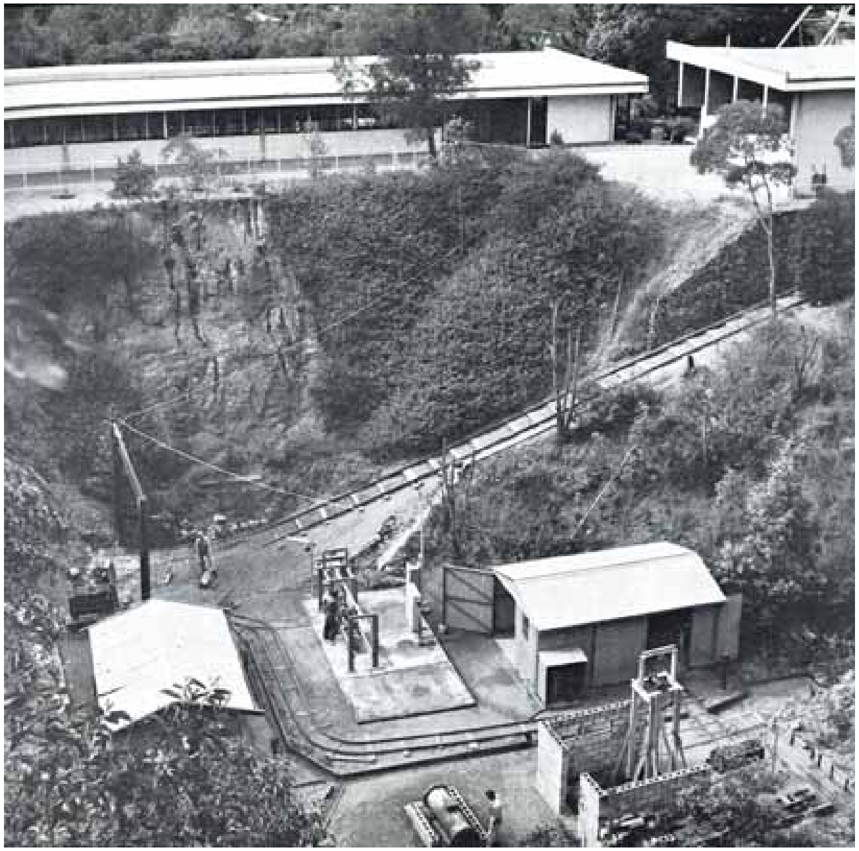
It is a substantial project which, we trust, will merit the support of the major mining companies of Australia, together with others concerned with the processing of minerals, such as cement manufacturers, refractory processing companies, and the like. In fact, the project is of such a nature that Mr. Foots considers that it should be discussed by the Council of your Association, which is representative of the types of organisation to which I have just briefly referred.

The concept involved in the project was initiated through discussions which I had with Mr. Foots some time ago and which, after preliminary discussions with his metallurgical research staff, has been prepared in the form of a more detailed statement.* I attach hereto 12 copies of the detailed outline of our proposals: further copies are available should you require them.

As you will see, the project concerns the eventual automatic control of mineral processing operations, with particular reference to grinding and flotation circuits. The details of our approach to the project have been outlined without belabouring it unduly and I now submit it at the suggestion of Mr. Foots for fuller consideration by your Association and, I trust, their support.

* forwarded under separate air mail cover.

Professor White's highly consequential letter to Beryl Jacka



Surface buildings at the UQ mine site in 1970, as depicted in National Development Quarterly

AN ENIGMATIC PROJECT TITLE

The successfully funded proposal became known as the Mineral Processing Project, then later the AMIRA P9 Project, or more commonly and succinctly – simply P9.

Quite curiously, nobody seems to remember exactly why it was designated P9.

"When I arrived at AMIRA in July 1968 there was no numbering system for projects and it became clear that one was needed," recalled Jim May, the first full-time AMIRA employee.

"I have no clear recollection of the way numbers were allocated to the existing dozen or so AMIRA projects, but it wasn't exactly in the order the projects commenced.

"The Mineral Processing Project should have had number 1, but somehow ended up as Project 9. So, P9 was the file number given to it and the number has been retained ever since."

By the time the funding came through, Alban Lynch was already established at the pilot plant at the Indooroopilly mine and opted to continue there, rather than relocate to the main UQ campus at St Lucia.

There was a certain maverick appeal at being at arm's length from the University, providing a heightened sense of self-determinism and a degree of latitude.

The P9 Project and Lynch's decision to remain at Finney's Hill were the fertile forces which later 'gave birth' to the existence of the Julius Kruttschnitt Mineral Research Centre, and its enduring location.

LEARNING AT THE COALFACE

In the days when the majority of University teaching and learning occurred on campus, research into mineral processing was commonly based in a laboratory.

Alban Lynch was not a fan of this approach.

Not only did he want his colleagues and cohort based at the former Indooroopilly mine site, but he also wanted them to venture out into the wider world and experience fieldwork at a variety of 'live' sites.

Lynch knew first-hand from his days in Broken Hill that valid, ground-breaking research could be successfully carried out in the environment of an operating plant.

And, as fantastic as the AMIRA funding was for P9, it did not include money for equipment, so the project required external facilities that were relevant to the industry's future.

At the time Mount Isa Mines were frustrated by problems with the throughput of their No 1 Concentrator, so they offered that up for research.

The No 1 Concentrator had been in operation since the first lead and zinc production in 1931.

Time spent by Lynch and his students in Mount Isa was often boiling hot, with a feeling of isolation, and on equipment which would now seem archaic.

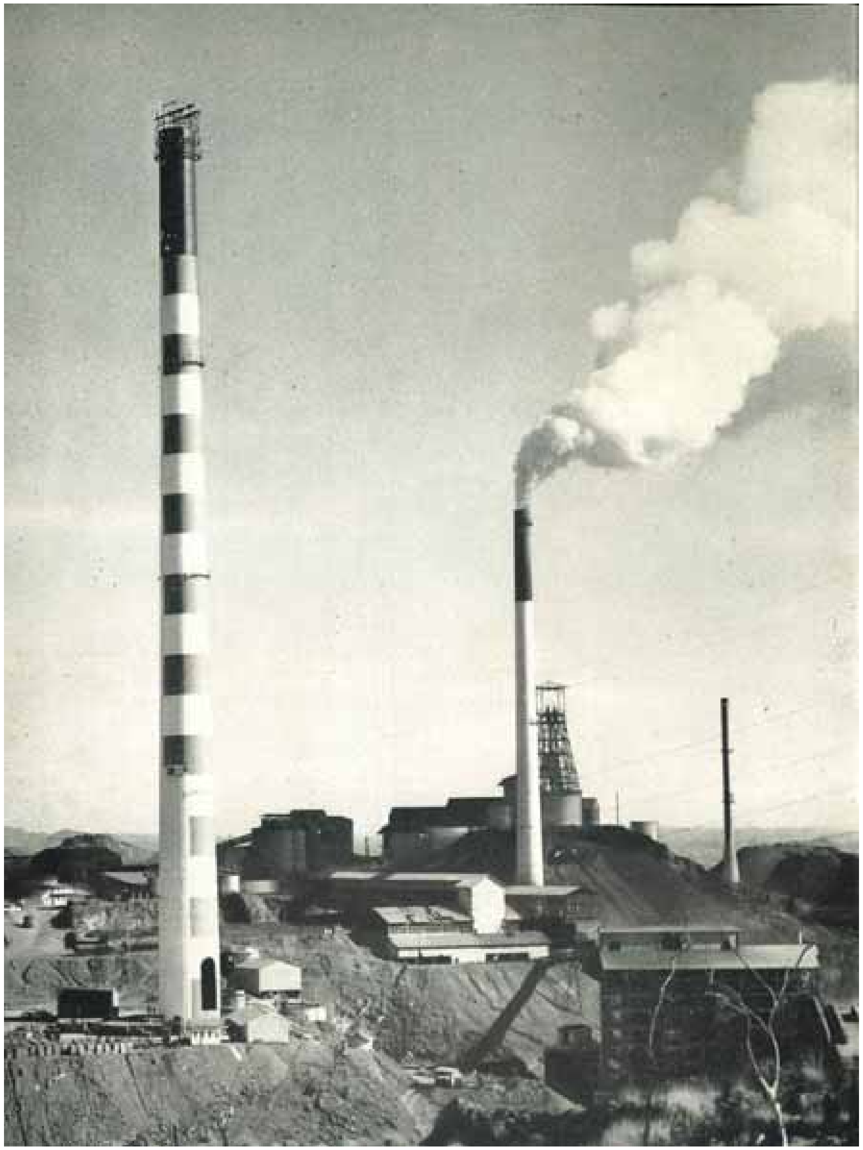
Yet the sense of a pioneering purpose never dissipated.

The successes from that time in Mount Isa are covered in greater detail in subsequent chapters of this book, and they laid the platform for many students and staff to find themselves on adventures well outside the boundaries of Brisbane.

ESTABLISHING THE JKMRC

Before Professor Frank White departed The University of Queensland in 1966 for McGill University in Canada, discussions had already advanced about a prospective collaborative minerals research institute that benefited both industry and UQ.

The seeds for something bold had been sewn.



Mount Isa Mines historical image

Plaque to commemorate the opening of the JKMRC

Officially opening of the JKMRC

White's successor, Professor Ray Whitmore, continued to support the concept, and in July 1969 a proposal for a research centre was submitted to the board of Mount Isa Mines.

The proposal recommended the company fund the construction of a new building at Indooroopilly, along with certain operating costs.

There were specific conditions around research projects and operating principles. These would become the operational 'bible' for the new centre.

The conditions included the necessity for all research to be of University standard, and sufficiently rigorous to attract funding from what is now known as the Australian Research Council (ARC).

Furthermore, it was stated that research should lead to improvements in minerals and engineering and to discoveries which would be freely published.

Other fundamental principles, not specifically included in the proposal, were that work was to be largely conducted in operational mine sites, and was intended to focus on 'big ticket' research issues.

Postgraduate students were to be the 'engine room' of the research and at the forefront of plans.

"The postgraduates were all very bright," Lynch said in reflection.

"At each site there would be an overall project with an overall objective.

"The postgrads would just go out there and work at it.

"I'm sure the best supervision came from the students talking among themselves."

As centre director, Lynch was free to choose the best people, support them in their endeavours and 'keep out of their way'.

A MOST WELCOME RECOMMENDATION

Sir James Foots – in those days known simply as Jim Foots – made a recommendation to his Mount Isa Mines board that the company should give The University of Queensland $100,000 to establish the mooted research building at the University mine.

That figure was equivalent to $1.2 million in the year 2020, providing adjustment for inflation.

Furthermore, a grant of $75,000 (now $900,000) per annum to cover a significant portion of operating costs was also proposed.

Finally, after a decade of operating on a shoestring budget in an overheated shed, the small team was jubilant.

One of the biggest mining companies in the country believed in their potential.

It seemed they had a future.

"In its structure, in the spirit and attitudes of its leaders and supporters, in its choice of people and their intellectual reach, their willingness to take risks and work all hours, the group Lynch had developed was unique," noted Don McKee.

"Lynch and his gentle autocracy gave students ultimate responsibility for their work.

"Critically he found a way to flourish within a traditional University in very non-traditional ways. He maintained necessary connections with the institution while operating in a very independent manner.

"He was decades ahead of his time in his ability to understand industry, conduct research of practical importance, and ensure the continuing financial support of industry.

"Decades later it is common to read impassioned pleas for industry and universities to work together on mutually important research topics and to train postgraduate students to understand industry and feel comfortable within the industrial environment.

Alban Lynch at work

"Lynch demonstrated exactly how to achieve these aims almost 60 years ago."

Outlook of the Finney's Hill area at Indooroopilly at the time the JKMRC was built

TEMPLATE FOR A BIG FUTURE

Few could have predicted that a modest project established by a small team was set for a giant future.

Those precarious early field projects, conducted only a few short months prior, transformed into something that would reshape the industry across the world.

By the end of the 1960s, half-a-dozen students conducting experiments in plants that would lead to higher research degrees had proven their knowledge and passion was worth supporting on a much larger scale.

The proof of their success was in the development of the Julius Kruttschnitt Mineral Research Centre, which became a reality at the start of 1970.

In partnership with the Australian Mineral Industries Research Association (AMIRA) and leaders in industry, the team was poised to become one of the world's major University training and research units focused on mineral engineering.

On 9 February 1970 Mount Isa Mines formally approved the arrangements negotiated for the establishment of the Centre

The naming of the centre in honour of Julius Kruttschnitt was a wonderful gesture, acknowledging his enormous contribution to not only the successful development of Mount Isa Mines, but also his broader impact on Queensland and Australian mining.

The dogged and determined way Kruttschnitt faced and overcame the challenges of the Australian landscape – both geographical and commercial – was admirable and an example to all of the mind-set required.

Mount Isa Mines had been critical to supporting the P9 Project throughout the 1960s and the naming of the centre was appropriate in reflecting that contribution towards sustained success.

The company's annual contribution of $75,000 towards expenses also supported the salaries of nine people.

THE EARLY 1970S – A PERIOD FOR OPTIMISM

The construction of a new building at the Indooroopilly mine site was symbolic to the close-knit staff and student group.

Together, they had laboured for years in a tin shed, but now there was a sense of permanency and progression.

The 1970s allowed the Julius Kruttschnitt Mineral Research Centre (JKMRC) to diversify and grow, expanding from a centre that focused on a singular project to one that was doggedly pursuing multiple simultaneous projects.

Julius Kruttschnitt attended in person when the new headquarters – featuring separate offices, a seminar room, student spaces, three general purpose laboratories and a remote terminal to the main UQ computer system – were opened on 5 May 1971.

The mining boom of the 60s and 70s was a double-edged sword for the JKMRC.

On one hand, the value of the Centre's work was more evident than ever, wages were attractive to those interested in entering the industry, and it appeared a line of study that could be sustained well into the future.

Conversely, the boom and accompanying record wage rises, combined with the OPEC oil crisis of the time, resulted in a period of rocketing inflation.

For a while Alban Lynch was certainly anxious about his ability to keep everything afloat, however, as always, he found a way.

Julius Kruttschnitt outside the centre named in his honour

Reception area at the JKMRC shortly after opening

New industry-funded research activities commenced, UQ chipped in by covering the salaries of two technicians at the pilot plant, and matters were kept on an even keel.

By the early 1970s, the fingerprints of the JKMRC could already be found on mining operations around the world.

Those students who had arrived in the 1960s had all completed their studies and quickly found positions in Australia and abroad.

Mal Lees went to Bougainville Copper in Papua New Guinea, Bill Johnson went to ASARCO in Arizona, USA, Peter Isles linked with Renison Goldfields in Australia, and the trio of Don McKee, John O'Shea and Peter Wickham all became involved with Mount Isa Mines.

It was an easy transition into industry for the graduates, who had grown to understand and develop an affinity for those environs via long periods conducting experimental work at plants.

THE SIGNIFICANCE OF ONE TOILET

In the 1971 configuration of the new JKMRC building was provision for an interesting feature – a female toilet.

Not only was the centre responsible for bringing together people of multiple ethnicities and backgrounds to share their wisdom, but it was also moving with the times and welcoming women into the mining sector.

One female employee who made her mark early – and was the subject of particularly fond memories – was Joan Richardson (nee Porter), first secretary of JKMRC.

She brought "discipline" to the centre, according to Alban Lynch, who also described her administrative style as "uninhibited".

Occupying a desk in the foyer, with a telephone connecting her to all extensions, she established clear rules for those attending the building and surveyed goings-on with an eagle eye.

From Gunnedah in rural northern New South Wales, Richardson was treated with great authority and respect by staff and students alike

The regard in which she was held was displayed when she elected to take time out of the workforce to raise her young children, having married engineer John Richardson and adopted his surname.

Despite 15 years transpiring, she was rehired by the JKMRC and continued in her distinctive and effective manner without skipping a beat.

Joan would often bring her dog to work – a Pembroke corgi named Samantha – and refused to make coffees for the men or clean up in the lunch room, such were her principles.

However, any other matter which fitted her job description was tackled with zeal and dedication.

"We were like family," Joan recalled.

"We used to have morning teas in the lunch room and were always laughing.

"When my mum was in hospital, I was away for six or seven weeks and the team carried me.

"When I had a car accident on the way to work, I phoned in to say I would be late, and all the students came out to see where I was and make sure I was fine. They stayed with me until it was all sorted out."

Even long into retirement, Joan still referred to Alban Lynch as Dr Lynch and could never bring herself to call him by his first name, such was the custom of the times.

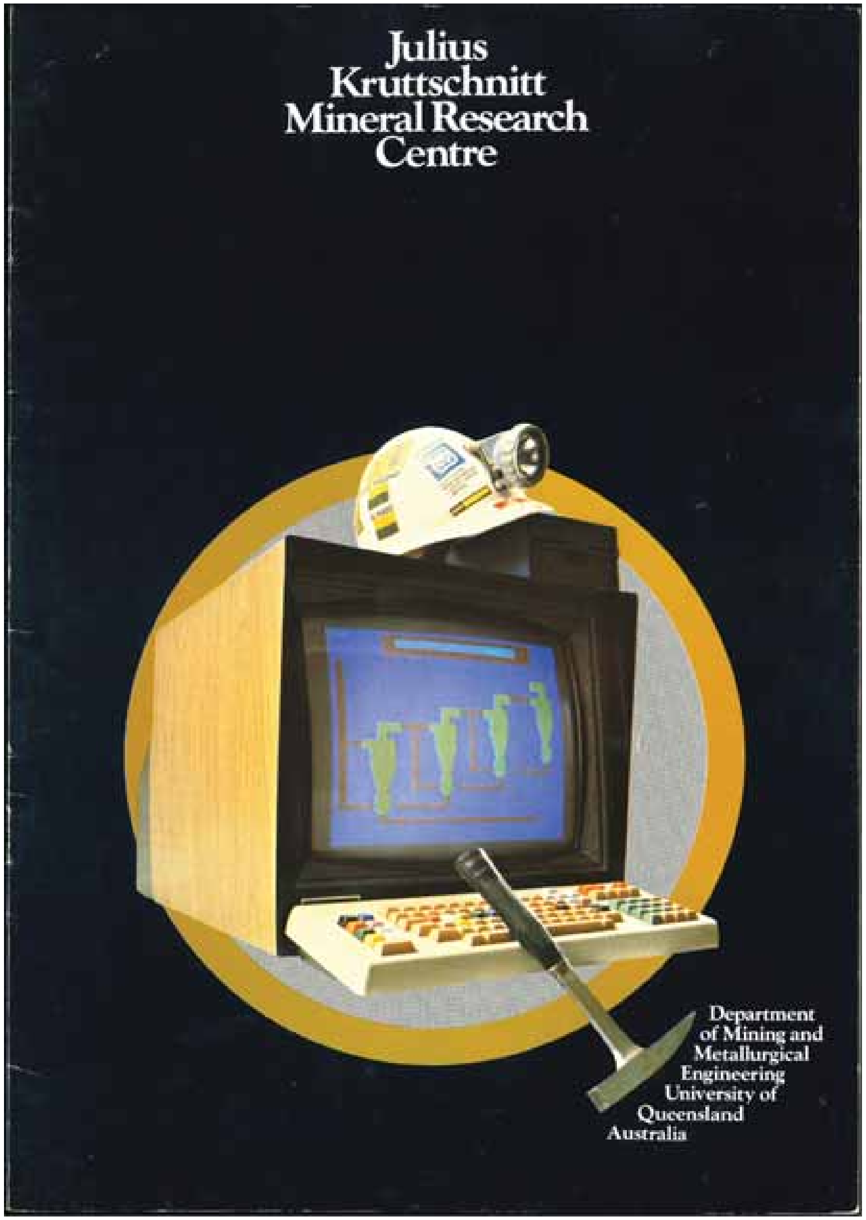
"Dr Lynch would walk around and talk to people, making everyone feel comfortable," she said.

"We had a permanent cleaner then, Mick O'Brien, and Dr Lynch talked to him as much as anybody else.

"He was one of the best bosses ever."

Collegial photo showing the fashion of the time

JKMRC cohort gather in the courtyard



Early flyer advertising the work of the JKMRC

AN ENDURING ENDEAVOUR

The success of the JKMRC was primarily based on its formula of tackling significant problems for industry, using the efforts of postgraduate students, and working in operational mine sites.

As news of the work of the JKMRC travelled, the centre became a magnet for ambitious and imaginative students from around the world who wanted to stretch themselves to the limit.

It became an organisation that attracted brilliant students and outstanding staff.

The other important ingredient in the JKMRC success was its position in The University of Queensland.

Although Alban Lynch was well-known for keeping the University at arm's length from his operation, he never doubted the value of being part of UQ.

It gave academic credibility with industry leaders, attracted high quality research students, and, despite occasional reservations between the University and its independently-minded mineral research centre, the University gave the JKMRC remarkable freedom to operate.

The JKMRC is, of course, different now from the free-wheeling centre of its first four decades, as it operates to a greater extent within the framework of the University. But the basic approach and underlying ethos continues - industry relevant research funded by the industry with postgraduate students at the core of the work.

Half-a-century of the AMIRA P9 Project was celebrated in 2012 – a fair achievement, considering the humble beginnings of the centre.

Remarkably, by the early 1980s Alban Lynch started thinking P9 had run its course and would perhaps be consigned to history.

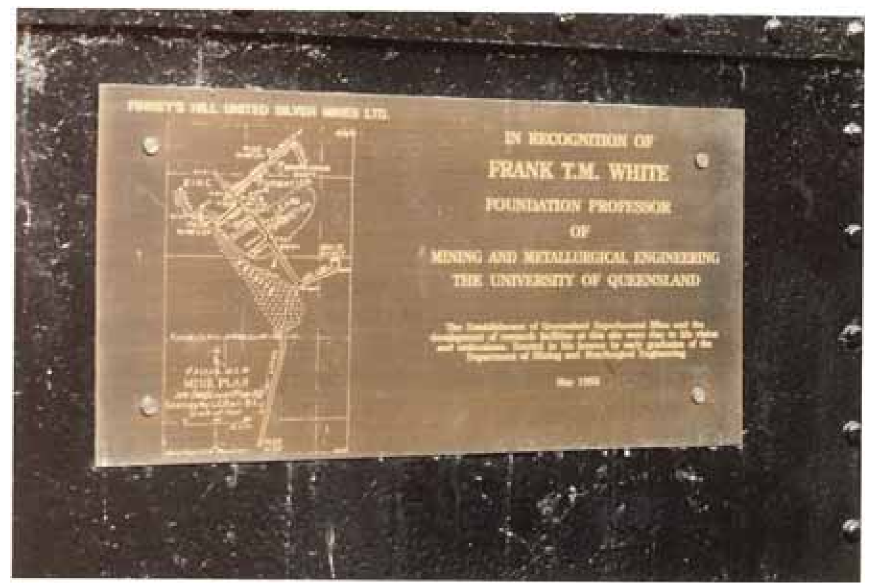
For once, Lynch was proven to be very wide of the mark.

The continuous procession of gifted students, strong leadership, excellent researchers and an ability to adapt to a changing world, all the while collaborating with industry, contributed to an ongoing relevance.

These aspects are covered in greater depth as you flick through the following chapters.

What started in the 1960s with a researcher and two students to find new – and more efficient ways – to grind rocks, had already turned into a multi-million-dollar research organisation within two decades.

Minecart on JKMRC grounds in tribute of Professor Frank White



Close-up of plaque in tribute to Professor Frank White

CHAPTER 2

DEMANDS OF A CHANGING WORLD

SHIFTING PRIORITIES

Like comparing athletes of different eras, there are many pitfalls in trying to measure the success stories of the Julius Kruttschnitt Mineral Research Centre side-by-side over numerous decades.

Aside from the constantly evolving technological, political and economic forces at play, from within the industry there have been rapid changes in the criteria used to determine advances.

For a long time in mining, the presiding concern was 'throughput' – the pure quantity of material that could be processed in a space of time.

At latter stages, the conversation turned to talk of 'efficiency'.

By 2020, the words on everyone's lips were 'sustainability' and 'regeneration'.

"A lot of people in the industry are involved and supportive of the change in direction, and the areas we are increasingly investing time, money and research into," noted Rick Valenta, current Director of the JKMRC.

"But you do admittedly get the odd comment like 'The work the centre does now is not a patch on what it used to do'.

"I think that's an unfair comparison to make, because the challenges we face now are fundamentally different.

"If you look at a problem such as the amount of copper we need to produce, in order to have the components for the necessary technology

Professor Rick Valenta

Technology has rapidly advanced since the rudimentary wooden barrows used in the early years of the Finney's Hill mine

to move to a sustainable future, you're working with increasing metal demand and lower metal concentration in ores, leading to an exponential increase in the amount of ore we have to mine and process.

"There was no such thing as 'clean energy', 'reduced environmental footprint' and 'social performance' to consider when the JKMRC began, and now it is at the heart of what we do.

"Between now and 2050, the amount of copper mine tailings we will produce is nine times the amount of tailings the mining industry produced in the entire 20th Century, unless we find more sustainable alternatives.

"Our challenges have grown exponentially, just as the population and ore production have."

TECHNOLOGY AND INNOVATION HAND-IN-HAND

It's impossible to separate the transformation of the Australian and global mining landscapes from the technological advances that have taken place in recent centuries.

In coming to exist in the mid-1900s, the Julius Kruttschnitt Mineral Research Centre was directly amidst one of the most rapidly evolving periods, particularly in regard to computer technology.

Since the 1840s, metalliferous mines had played a massive role in shaping Australia, pre-federation.

Whether it was copper extraction in South Australia, the Victorian gold rush and subsequent gold discoveries in Kalgoorlie and Coolgardie, lead and zinc in Broken Hill, copper at Mount Lyell, then silver, lead and zinc at Mount Isa – there were challenges that needed to be overcome.

The ingenious ways in which knowledge, machinery and effort combined to make every obstacle surmountable, was something to be admired.

All that being said, in 1950, the Australian metalliferous mining industry was still very much the pre-World War II industry. Mining was active only at deposits discovered from the 1850s to the 1930s.

The industry was static. Coal production was restricted to long-established mining areas in New South Wales, Queensland, Victoria and, to a lesser extent, in South Australia and Western Australia. Iron ore, copper, lead and zinc, tin, gold and minerals sands were other commodities where there had been few new developments.

The mining industry was significant but lagged behind agricultural production in economic importance.

The first significant sign of change was the emergence of uranium activity. Rum Jungle in the Northern Territory (1954), Radium Hill in South Australia (1955) and Mary Kathleen in Queensland (1958) were developed to supply uranium oxide concentrates for nuclear power and weapons in the western world.

Exploration programs gathered pace and two discoveries opened the way for new mining activity. The iron ore deposits found in the Pilbara of Western Australia were deemed to have immense potential. Bauxite was also discovered at Weipa in Queensland and the Darling Ranges in Western Australia.

The implications were obvious – there was an opportunity to develop major mining and treatment operations based largely on the export of iron ore, alumina and aluminium.

Fortunately, international markets beckoned. Likewise, the demand for existing base metals, particularly via export, was only going to soar.

The development of large coal mines in Queensland and New South Wales for export of coking and steaming coal was just round the corner. As the 1950s ended there was a sense of great opportunity and optimism within the minerals industry, sentiments which were boldly captured in the next decade.

In the 1960s the focus in technical advances shifted dramatically.

The since-closed uranium mine at Mary Kathleen in Queensland

Comalco bauxite mine at Weipa, Queensland. Credit - Urbain J Kinete

A giant power shovel operates in the Pilbara area alongside 95-tonne trucks

BHP publication heralds first shipment of Manganese from Groote Eylandt

Previously, much attention had been invested in making operations possible, engineering equipment that would circumvent nature's will.

But then, the spotlight fell on making things more efficient – in economic, labour, safety and time terms.

The proud history of Australian ingenuity combined with a rapidly expanding industry and enlightened management who understood the need for research, shaping what was to come.

DEVELOPING NEEDS OF INDUSTRY

The 1960s stand supreme in Australia for the number and significance of new mining and processing ventures which transformed the industry and formed the backbone of the nation's export economy.

Equally importantly for this story, the 1960s spawned a new era in technical development and innovation, supported by a steadily growing research sector.

The bauxite and iron ore discoveries of the 1950s were quickly transformed into mining operations. Bauxite production at Weipa and south of Perth commenced in the early 1960s with alumina refineries and the first smelter soon after. In remarkably few years Australia had a fully integrated aluminium industry.

Iron ore mines in the Pilbara commenced production in the mid-1960s with associated rail and port facilities for export, particularly to Japan.

A massive coal export industry emerged in the Bowen Basin in Queensland and in New South Wales. Manganese mining commenced at Groote Eylandt in 1965, again with an export focus.

The unforgettable nickel boom was sparked by the discovery of nickel ore by Western Mining Corporation (WMC) at Kambalda near Kalgoorlie, closely followed by other discoveries in the region. By the end of the decade Kambalda was in production, along with an associated smelter.

During this decade, the great mines at Mount Isa and Broken Hill were undergoing major expansions to increase copper, silver, lead and zinc production. And, although not an Australian operation, construction of the massive copper mine and processing plant was underway on Bougainville using Australian expertise, with first production following in 1972.

These were no ordinary deposits.

The 1950s and 1960s were golden decades, marked by quick thinking and bold management action to capture the export opportunities in Asia and Europe.

THE CHANGING FACE OF FUNDING

As legendary and central as the P9 Project was to the establishment of the JKMRC and its subsequent years, it does need to be placed in perspective.

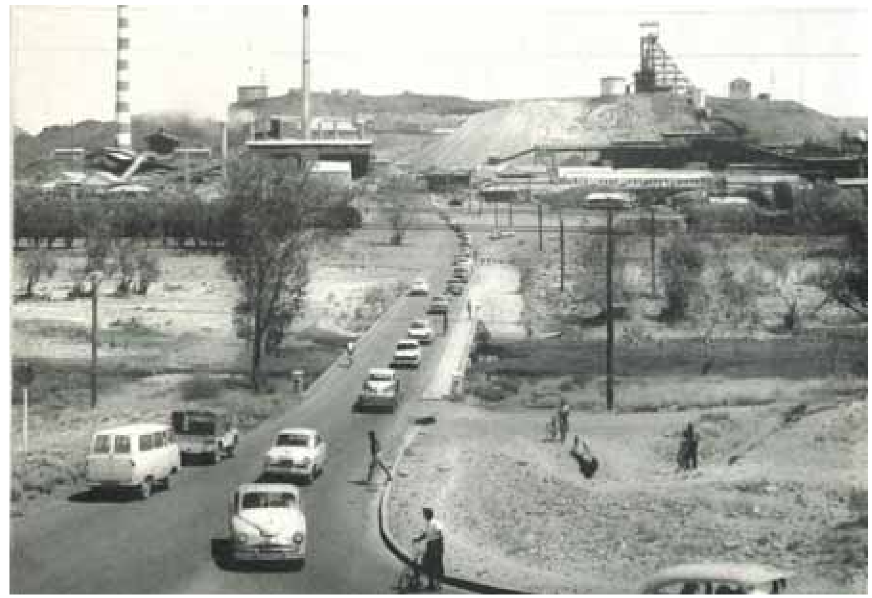
At the time the initial funding was supplied, varying levels of government were actively campaigning to encourage expansion of the Australian mining sector.

Relationships between government, research organisations and industry – and how they are managed – have changed since the mid-1900s.

The AMIRA P9 project was set up at a time when there was a shortage of people with knowledge of mineral processing research.

It was expected that research institutions participating in P9, particularly the JKMRC, would deliver people who would help shape the industry, which it did.

Today companies sponsoring research primarily seek to identify shorter term economic benefit from research and the production of skilled researchers is of a secondary concern.



Mount Isa abuzz with activity as mining thrived

Professor Tim Napier-Munn

Anecdotes outlined by sources in the compilation of this book revealed how different eras spawned different methods of negotiation. In some early cases, deals were struck after relatively brief face-to-face meetings that hinged on interpersonal confidence and a handshake. As the years progressed, more formalised processes with elongated checks and balances became more the norm.

In following chapters you will also note how varying incentives and funding sources came into prominence at different stages of the JKMRC's evolution. When one source of funding supplanted another, it often meant tinkering with the priorities and workflow of researchers to meet the specific requirements of the new program.

THE ROLE OF GOVERNMENT FUNDING

The winds of change were blowing when the Cooperative Research Centres (CRC) program was launched by the Australian government in 1991.

Designed to provide medium to long-term industry-led collaborations, the CRC program used matched funding in an attempt to improve the competitiveness, productivity and sustainability of Australian industries.

The growth in CRCs in the 1990s changed the research landscape enormously. One of the most challenging changes was produced by the notion of Intellectual Property (IP).

JKMRC staff felt the effects of this in the new requirements by some companies for ownership of newly developed technology. Many wanted the competitive advantage associated with legal ownership.

The Centre was caught on the hop by the implications of IP and so was AMIRA. It was not until the end of the decade that contracts with AMIRA had clauses associated with IP. Up to this point IP was largely owned by the PhD student or, by virtue of being published in academic papers, was not 'owned' by any single entity as the publishing of the idea put it into the public forum.

Once the value of IP was recognised it became apparent that universities needed to own their IP, and for this to be recognised by contracts, so that they would not be locked out of doing further research on ideas that they themselves had created. Of course, companies that had paid for the development of the research projects also felt they had a right to ownership of the IP.

The advent of CRCs brought these complexities to centre stage, necessitating lengthy legal deliberations again complicated by the fact that government funds were also provided as part of the CRC model.

Furthermore, the JKMRC had never been a consistent player in Australian Research Council (ARC) grants. However, the centre had been successful with ARC Linkage grants, which involved funding from the industry and ARC.

In what turned out to be a sustained effort, Professor Tim Napier-Munn worked with other Australian universities active in minerals research and leading companies to come together to develop an ARC Linkage proposal to fund fundamental research in mineral processing.

The result was the Australian Mineral Science Research Institute (AMSRI) which began in 2006 and ran for five years with funding of $22m from ARC, the South Australian Government, six companies and from the research participants, the Universities of South Australia, Melbourne, Newcastle and the JKMRC.

At the time, it was the largest ever ARC Linkage grant in the field.

Participation in AMSRI brought benefits to the centre, particularly in mineral liberation studies, when comparing breakage from a range of devices. One of the most important was a study of high voltage pulse breakage of rock,

Discrete element modelling codes were applied to particle breakage to improve fundamental understanding, providing the basis for current work. This research continues today as the High Voltage Pulse project under the leadership of Professor Frank Shi.

Research happening on-site at the JKMRC's Indooroopilly location

Mount Kembla mine disaster of 1902

Mount Mulligan coal mine explosion of 1921

SAFETY AND SAVING LIVES

In 1887 the Bulli mine disaster killed 81 people. In 1902 the Mount Kembla disaster killed 96. Later in 1921 the Mount Mulligan mine explosion took the lives of 75.

Those numbers are almost unthinkable in Australia's mining industry today.

At the time of writing, five people had been killed in all mines across Australia in 2020, incidents which remain tragedies regardless, but by comparison form a sharp decline since the industry's early years.

Similarly, statistics from the USA show that annual deaths from coal mining alone were measured in the thousands each year, right up until 1947. In recent times, the number of deaths per annum in US coal mining has rarely exceeded a dozen.

"I would venture that it's absolutely fair to say that the JKMRC has helped save lives over the past five decades with what it has done," Rick Valenta said.

"Anything that removes the need for a human being to be in harm's way directly contributes to the preservation of life.

"I don't want to pretend to have any more knowledge than the next person in regards to safety but it was only a few days ago our head of safety was saying one of the continuing trends of mining technology will be taking people out of harm's way.

"We're already at a stage where someone can do a Zoom call and everyone else sees what they see. In 10-15 years it'll be more commonplace to be seeing things through the eyes of a robot.

"Beyond that, it will be a robot with artificial intelligence who doesn't need a human operator unless faced with exceptional cases."

THE FUTURE IS CROSS-DISCIPLINE RESEARCH

"When I became Director of The Production Centres at the JKMRC and the WH Bryan Mining and Geology Research Centre in 2015, it was clear that we needed to look outside traditional approaches to mineral processing research," says Professor Alice Clark.

"The research team at the JKMRC had realised that minerals were vital to a sustainable future and everyone was grappling with the concept that the solutions existed outside their research focus area.

"At that time there were, within the JKMRC, distinctly separate groups who as individuals were extremely focused on their particular speciality within the mineral processing field. It might be flotation, or comminution or energy. In fact they were undoubtedly experts in their respective fields.

"With the re-location of the BRC to the site world class mineral processing experts now shared space with equally renowned geoscientists. What was exciting was watching the teams shift, grow and align to work together across disciplines to solve problems.

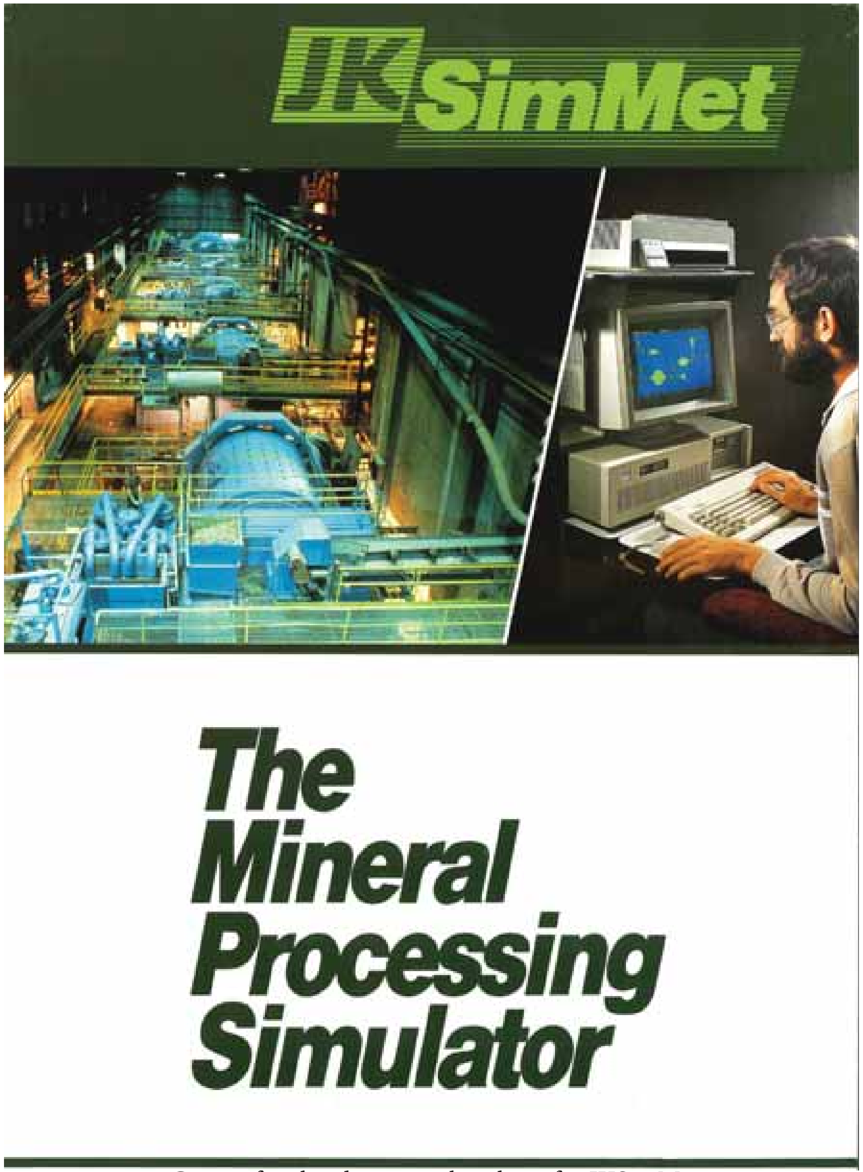
"It's hard to describe how courageous it is for a scientist or engineer who has spent their whole career building expertise in a particular field, embrace a strategy of cross-discipline research where new groups of people work together to share ideas that eventually solve problems.

"This shift in thinking that resulted from the W. H Bryan Mining and Geology research group relocating to the Indooroopilly facility and teaming up with the JKMRC to conduct true cross-discipline research enabled step-change research aimed at reducing the use of water, energy and waste materials in the mining process through geometallurgical approaches.

"Within three years we had commenced nine PhDs where the focus was on research that spanned geology, mining engineering and mineral processing.

"Creating an environment where that can happen was a credit to the team of researchers at the JKMRC."

Professor Alice Clark



Cover of early advertising brochure for JKSimMet

As part of this initiative, in 2016 Clark disbanded the separate JKMRC and BRC advisory boards and formed a new combined advisory board whose aim was to seek opportunities to link research across traditional areas of expertise and skill while continuing to provide applied research outcomes within the traditional areas of speciality of the two centres.

COMMERCIAL VALUE OF RESEARCH

Throughout the world there was an increasing awareness of the commercial value of University research, along with the growth of small enterprises using computer-based technologies.

This confluence was precisely where JKMRC found itself.

Fortuitously, this coincided with The University of Queensland's growing positivity towards previous unexplored avenues of commercialisation.

The JKMRC excelled in developing new research areas and anticipating the technical needs of industry.

The modelling, simulation and control work of P9, the blasting project, the developments of JKSimMet (computer software for the analysis of comminution and classification circuits), ASHSCAN (providing real-time, continuous data on total ash content in coal) and the foundation work which resulted in CSIRO's QEM*SEM (creating maps of a specimen surface scanned by a high-energy accelerated electron beam), and the mineral sands project were examples of innovative projects.

FLUCTUATING ATTITUDES TO MINERALS

At different stages of the JKMRC lifecycle, some mineral commodities have ridden wild oscillations of both commodity value and society's attitude towards them.

Uranium was the impetus for much excitement in Australia mining circles in the early years, then became an almost unspeakable word, and now is being reconsidered for viable uses.

Similarly, coal has traditionally been seen as the lifeblood of many Queensland cities, but attitudes towards it have also changed. At the time of writing, Adani's Carmichael coal mine in the Galilee Basin was still garnering headlines and dividing public opinion in a manner reserved for the biggest issues of the day.

Subsequently, when the history of the JKMRC is placed in the spotlight, it's noticeable how attitudes and public sentiment drove different eras.

For instance, when Gideon Chitombo assumed the role as mining research manager, it became clear he was not a supporter of coal mining.

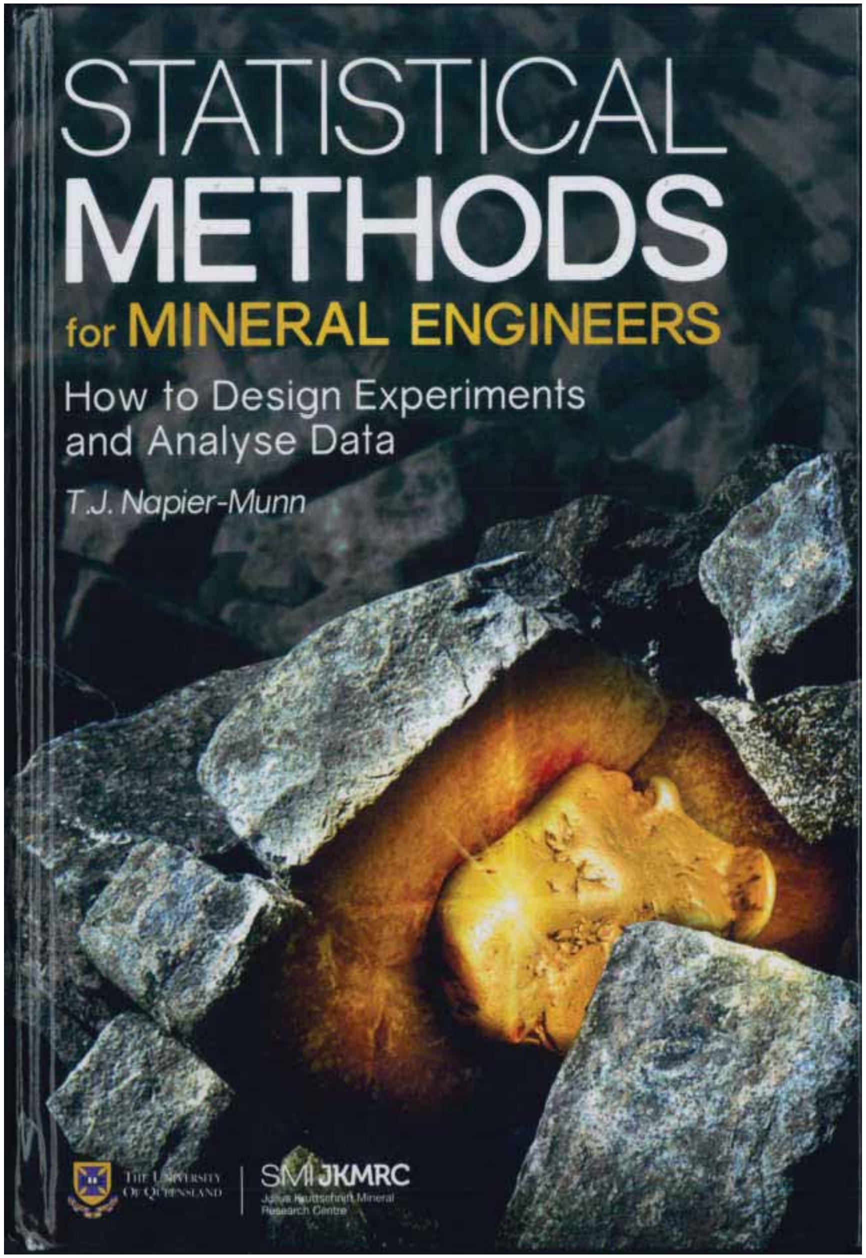
The emphasis of the group in which he worked therefore developed around research associated with underground metalliferous mining, while continuing software development and blasting fundamentals.

New coal-related activities within JKMRC diminished quickly, with the exception of some coal preparation work carried out under the direction of Chris Wood, with research continuing in modelling of dense medium cyclones and coal washability data.

In 1994 Wood joined JKTech, which will be covered in greater depth in subsequent chapters, to develop consulting in coal preparation. His replacement, Peter Holtham, enjoyed a long and successful career at the JKMRC himself, initially expanding the scope of coal work with projects around spirals, coal distributors and a coal version of mine-to-mill.

While the focus on coal research diminished, JKMRC researchers ensured they didn't lose touch with the industry, staying at the forefront of developments.

Professor Gideon Chitombo



Statistical Methods for Mineral Engineers written by Tim Napier-Munn

BOOK IT IN

While it's not what most people immediately associate with a mineral research centre, one of the JKMRC's biggest success stories has been the books it has produced.

Referred to as monographs – specialty books written on specific subjects from an academic point-of-view – these titles are a big reason for the global renown of the centre.

Indeed, for some researchers and students, reading a monograph has been their first introduction to the JKMRC.

"I'll never forget when I joined Anglo American Platinum and the boss walked in and gave me a recent P9 Project report and the JKMRC blue book and told me I needed to understand the flotation and comminution models," current SMI Director Professor Neville Plint.

"After that, I went and read Tim Napier-Munn's monographs (*Statistical Methods for Mineral Engineers* and the co-written *Wills' Mineral Processing Technology*) which are really *the* reference books for mineral processing and statistics for mineral processing.

"From there, I then went on a training course run by the Steve Morell and Tim Napier-Munn from the JKMRC. It was easy to see why so many people in the mining industry come to revere the centre from an early point in their careers.

The JKMRC celebrated its 25th anniversary in 1995 by publishing the titles *Mineral Comminution Circuits* and *Open Pit Blasting*.

The costs to produce the publications were met by 10 companies and the University, which said a great deal for the industry and University support the Centre enjoyed.

In total, nine monographs have been written and published, seven published by the JKMRC itself, embracing comminution and classification, flotation, blasting, cave mining, mass balancing and metal accounting, statistics and mineralogy.

Many of these have become standard texts, and they represent one of the most important achievements of the centre. No other mineral processing research group has done anything of the same scale.

MINE-TO-MILL

An important new research direction took place in the early 90s, with the beginning of mine-to-mill thinking.

Historically, all the separate stages of mining had largely existed as separate parts, with only a bare minimum consideration for how each stage affected the next – and subsequently the operation's overall performance.

Until then, as Don McKee quipped, the mining teams and processing teams had existed in "splendid isolation" from one another, both at the JKMRC and within major mining companies.

Mine-to-mill was the philosophy of looking at the entire operation in a holistic sense, identifying where logjams, unnecessary expenses and compounding issues may occur.

By linking the expertise and modelling of the JKMRC's mining and processing groups together, investigating the potential of tailor-made solutions was now much more straightforward and practical.

McKee pushed this thinking strongly, with simulation used to show the overall gains possible by linking the mine and mill.

A site-based case study in 1995 by Toni Kojovic, Ray Wedmaier and Nenad Djordjevic further confirmed the concept.

A new AMIRA Project, P483, the Optimisation of Mine Fragmentation for Downstream Processing, commenced in 1996.

When P483 concluded in 2002 numerous case studies had demonstrated the practical possibilities for improved performance by directly linking aspects of mining and processing activities.

Professor Don McKee

Once again, the JKMRC had pioneered new territory and given a lead to the industry.

Mine-to-mill applications became routine in the industry.

KEY COMPONENT OF THE SUSTAINABLE MINERALS INSTITUTE

Sustainable Minerals Institute Building

In the year 2001, the JKMRC came to fall under the umbrella of the Sustainable Minerals Institute (SMI), a collection of research centres working across the entire mine lifecycle.

Each centre had a commitment to delivering sustainable resource development, while training the next generation of industry and community leaders.

The SMI as a whole had two initial goals.

The first was to develop new research areas and, in this, it was successful. Much of the effort, particularly in the early years, went to achieving this aim.

The second goal, which was always going to be a greater challenge, was to bring together the various individual centres and develop new research opportunities by combining their expertise.

Early attempts towards this goal, where SMI seed-funded small collaborative projects as the basis for larger joint activities, did not have the desired result. The centre directors all supported the goal but, not surprisingly, their main focus was on their own centres.

It was not until 2006 that successful multi-centre projects were under way. Ironically, the first was not for the industry but for the Queensland Government.

This was a period when the JKMRC branched into new research fields which were complementary with the established mining, processing and coal preparation work. Projects associated with discrete element modelling (DEM), computational fluid dynamics (CFD) and tomography expanded the modelling capability of the JKMRC. With the availability of the Mineral Liberation Analyser (MLA), work on mineral liberation began in earnest.

The JKMRC contributed to the development and delivery of courses for external Masters degrees in mineral processing.

SMI workshops showcased the cross disciplinary work of the JKMRC, the Minerals Industry Safety and Health Centre (MISHC), Centre for Social Responsibility in Mining (CSRM) and Centre for Water in the Minerals Industry (CWiMI). JKMRC was a participant in association with the WH Bryan Mining and Geology Research Centre (BRC), Centre for Mined Land Rehabilitation (CMLR) and CWiMI in seed projects funded by SMI to develop opportunities for new collaborative activities linking the expertise of the SMI centres.

DIVERSE RESEARCH PROJECTS

Endeavours launched in the early 2000s showcased the diversity of new research supporters for the JKMRC.

It was a major departure from the AMIRA and ACARP domination of the 1970s through to the 1990s.

De Beers funded the Diamond Value Management project for five years.

The project set out to improve dollar-per-tonne revenue across De Beers group of mines, and a particularly strong partnership was formed. Further information on the De Beers partnership can be found in the *A Global Impact* chapter.

The most recent major new AMIRA project for the JKMRC, the Geometallurgical Mapping and Mine Modelling project, always known as the GEM Project, commenced as AMIRA P843 in 2004.

This activity was conducted in collaboration with the CODES group at the University of Tasmania.

Dr Anita Parbhakar-Fox started out as a research assistant on the GEM project

Adjunct Professor Ben Adair with late colleague and friend Dr Dan Alexander

It was vintage JKMRC, giving substance to the relatively new theme of geometallurgy, linking geological attributes of an orebody to aspects of mining and processing, through collaboration with another University.

For the best part of 40 years AMIRA had been the main vehicle for industry-funded research.

But by 2010 AMIRA had ceased to be the automatic choice for JKMRC research. This partly reflected industry thinking which saw competitive advantage in owning, rather than sharing, research outcomes in the form of IP. The advent of CRCs had also changed the research landscape, effectively providing alternatives to AMIRA.

JKMRC research projects with individual companies had been a feature of activities since the mid-70s, but never in a major way.

This changed in 2009 when Ben Adair (JKMRC director at that time) negotiated a major research project with Rio Tinto, resulting in the formation of the Rio Tinto Centre for Advanced Mineral Separation. The Rio Centre is part of the story of the next decade and it marked a significant deviation from the traditional industry-funded research.

THE EFFECTS OF LOSING KEY PEOPLE

Highly specialised knowledge and a fiercely loyal workforce that remained on board for decades proved a double-edged sword for the JKMRC.

While any organisation suffers from staff turnover, the peculiarities of the JKMRC meant it was an advent that was acutely felt whenever it occurred.

Success breeds both interest and opportunity, and graduates and employees of the JKMRC were highly sought-after as the centre's success compounded year after year.

Whenever a key person departed – whether through opportunity elsewhere, retirement, family commitments, or sadly death – it took a lot to fill those shoes.

Because many of the early researchers had not wanted to work anywhere else, and been such a tightknit group, when the course of nature dictated otherwise, it set the JKMRC aback.

It's no coincidence in reflection, that there were some periods where stability and research pursuits were unsettled more than others, notably when multiple key personnel left around the same time.

Of course, the flipside is that as one door closes, another opens. While many figures seemed irreplaceable and left a huge hole, an opportunity was then presented for someone else to make their mark and grow into the role.

EMPHASIS ON University RANKINGS

The playing field for The University of Queensland, not just the JKMRC, continued to change.

A University's position on the numerous global rating ladders was becoming increasingly important. International students became an even more important – almost vital – spoke in the wheel of UQ.

Institutions well-placed on rankings attracted more of these undergraduates, not to mention the best postgraduates, professional and academic staff.

Ratings were heavily influenced by publication in prestigious academic journals and JKMRC had never been a star performer in this area, because its predominant focus had been on applied research in collaboration with industry partners and maintaining a stellar reputation among those who orbited in mining circles.

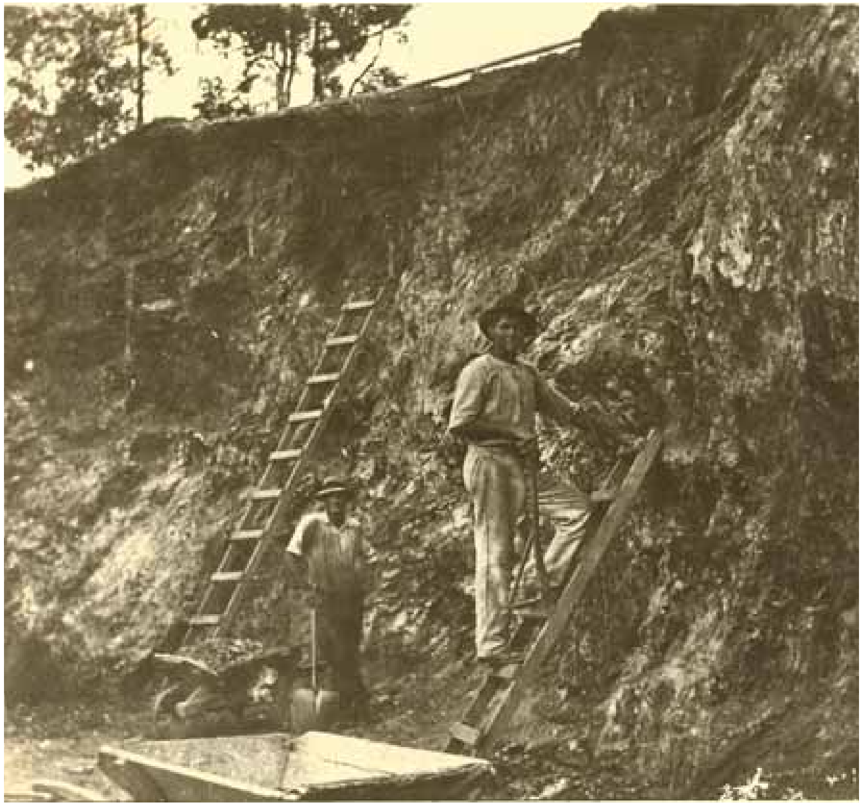
The centre had always been a strong participant in major industry conferences where the companies were represented, as well as in the wider world of mining and associated journals.

Yet those publications had reduced impact in the academic world. It was not a new phenomenon but by the mid-2010s the JKMRC was being strongly encouraged to adjust its publication strategy.

The University of Queensland's main campus at St Lucia, Brisbane, Queensland

The JKMRC often attracts its alumni back to the research family. Some say that no one ever really leaves the JKMRC – they temporarily depart until their imminent return years or decades later, ready to contribute greater experience and insight into the centre's research.

UQ is consistently among the top-ranked universities in the world



The JKMRC has been able to live and learn off the back of tough times, such as those experienced by the Finney's Hill mine in the 1920s

Research staff within the JKMRC took up the challenge and steadily increased publication submissions to high-ranking journals. As ranking criteria adjusted, so too did the strategy of the research staff who recognised that they served two masters – a University that required academic excellence as evidenced by publications (amongst other things) and an industry that sought applied solutions to the problems they faced in their operations.

In addition to high-ranking journals, the ranking system moved to encourage academics to co-author papers with industry representatives. But with the strong links to industry this was a challenge the researchers at the JKMRC were almost genetically engineered to achieve.

SURVIVING TOUGH TIMES

Since its effective beginning in 1962 it is no secret that the JKMRC endured some tough times.

None were tougher than the first seven to eight years of the 2010s, as the Centre weathered a major industry downturn, the Global Financial Crisis (GFC), a quest for a modern identity and difficulties on a number of other fronts – challenges not too dissimilar to those experienced by the Finney's Hill mine site in the 1920s.

That the JKMRC emerged by the end of the decade with re-focused energy and a path forward is due to strong and effective leadership, the unfailing strength of the students, the emergence of a new group of research leaders, the engagement with industry and above all, the essential support of The University of Queensland, both financial and moral.

While it is a different centre from the one which many early alumni will remember, the essential ingredients of conducting quality research relevant to the industry, based in large part on the work of postgraduate students, remains strong and unchanged.

This was the decade when SMI really set out to make the centres an integral part of the Institute. It was also the period when SMI became more integrated within the University.

This change accelerated when the leadership of SMI changed in 2016 and by 2020 there was no doubt that the focus had shifted to delivering integrated transdisciplinary disciplinary research to address the complex challenges facing the sector.

The 2014 SMI Annual Report noted the year had been a hard one, with the centre unable to renew a number of staff employment contracts. There was no single reason, rather a combination of factors. The industry had entered an extended downturn phase and for many companies, funding research was not a high priority. However, the centre had weathered a number of industry downturns in its history, so the current situation was not the sole reason for the problems. New project development proved very difficult, exacerbated by shortage of research staff with the necessary skills for an always demanding task.

Both staff and students who lived through the difficult years agree that it was a tough period, but one which gave a necessary impetus to the vision for the future.

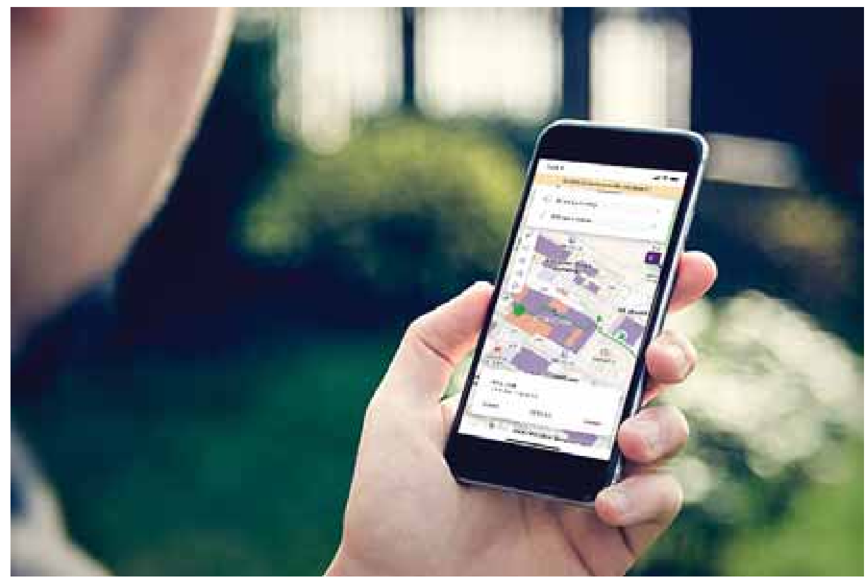
INFORMATION OVERLOAD

The rapid advances in digital technology that accompanied many of the JKMRC's greatest breakthroughs also pose many of the centre's greatest problems for the future.

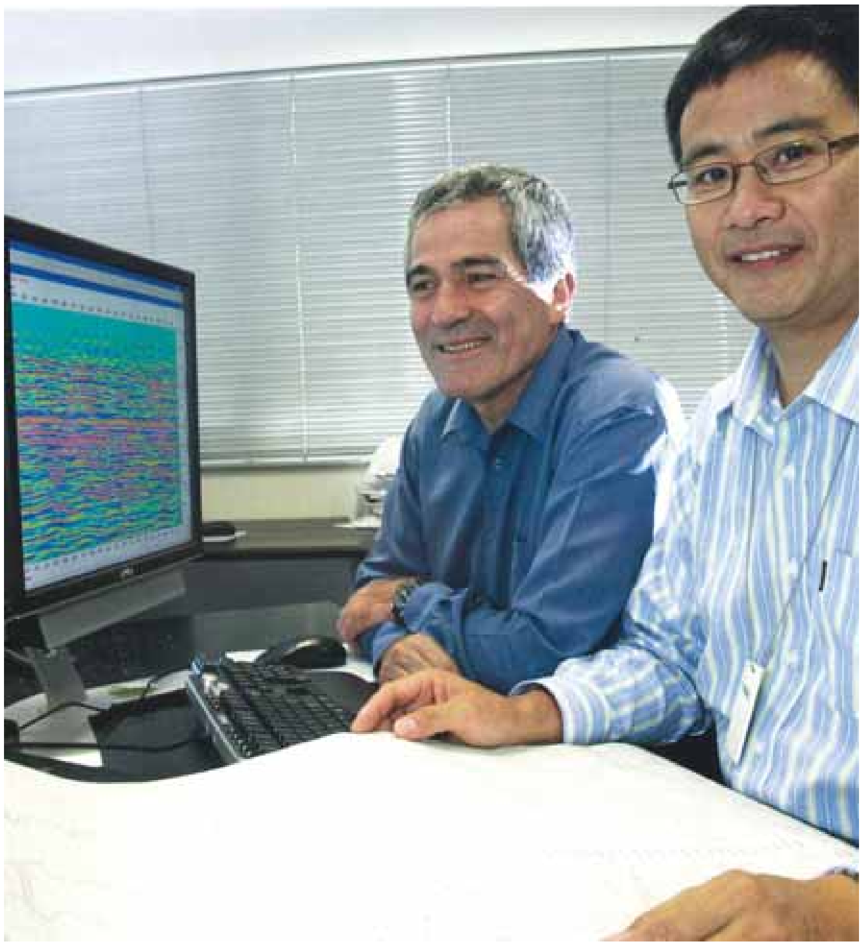
As within other areas of industry and academia, the constant capture of data has led to challenges in storage, hardware, software, and sifting through the haystack to prioritise the most meaningful information.

"There is no way the researchers of 50 years ago could have anticipated that one day I'd be standing here with a phone in my hand that is many, many times more powerful than the computer they had to use back then," said Rick Valenta.

The Research Computing Centre at UQ



Mobile phones revolutionise the way researchers can conduct and cross-reference their work



Reviewing seismic and borehole log data, Credit - David Kapernick

"Mines are becoming overloaded with sensors that spit out all sorts of information that lead to efficiencies, but the reality of sensors being in everything takes us in another direction.

"Certainly, there is a prospect of information overload, especially under current set-ups where you may have two human monitors looking at 20 screens.

"Another factor is that, in many places, all the interpretive knowledge is in the heads of the human monitors and it hasn't been fully captured elsewhere. We need to move away from a situation where we are relying on individuals alone.

"In the future I can see a situation when the geologist and metallurgist are only called upon when the computer is not capable of analysing all the boring stuff. The humans will be overseeing multiple computers who do all the monitoring and control, and don't go in until the artificial intelligence hits a wall."

Valenta said one of many important lessons the JKMRC had learned over the years was that it wasn't simply enough for computer technology to analyse and identify problems, but it also needed to boast an interface that didn't require the skills of a computing genius to interpret, but it also needed to boast an interface that didn't require the skills of a computing genius to interpret.

CHAPTER 3

STRIKING GOLD AS TECHNOLOGY ADVANCED

DANCING WITH THE DIGITAL ERA

The University of Queensland ordered its first computer in 1961, and it became operational in 1962.

It was far removed from modern times, where a personal computer is taken from its box and ready to go in a matter of minutes.

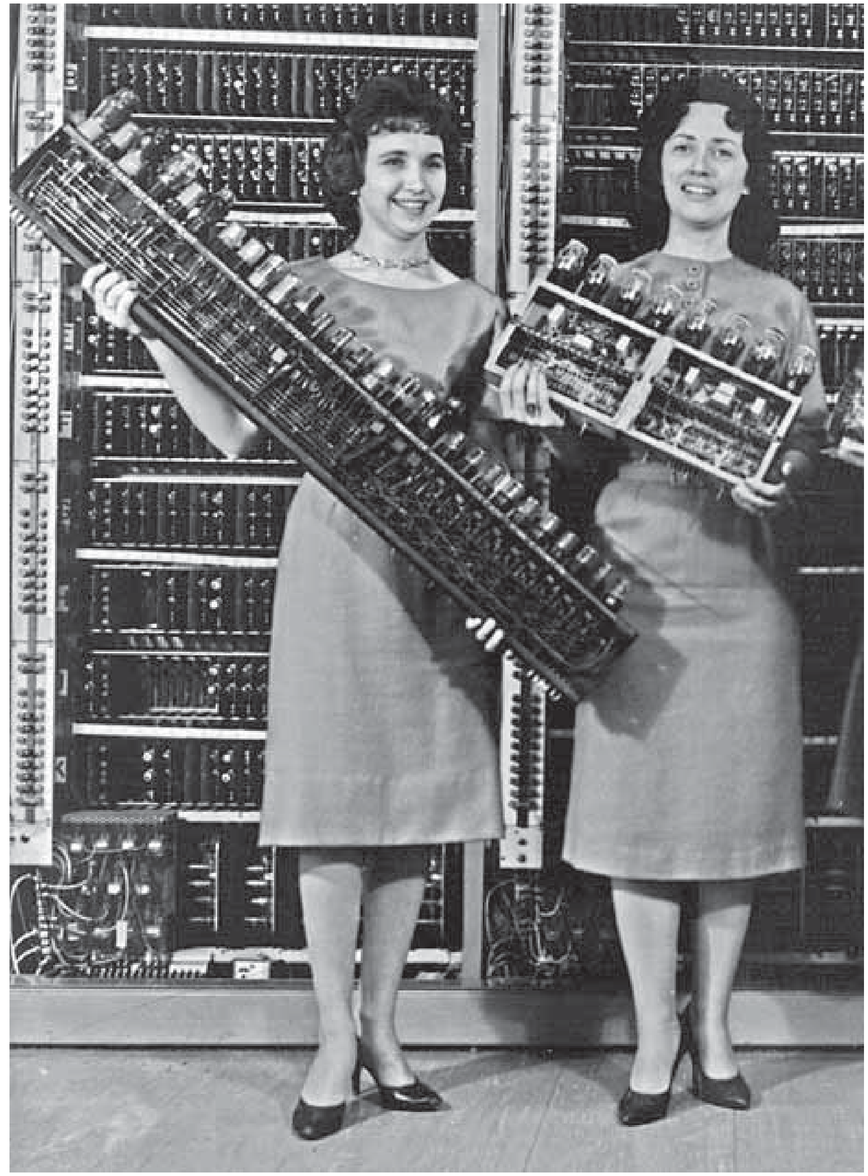
Consider the purchase of the University's first computer against the backdrop of what else had occurred – and was occurring – at that time.

The mine site which became the home of the Julius Kruttschnitt Mineral Research Centre had been acquired in 1951. Pivotal figure Alban Lynch arrived at UQ in 1958. The crushing house and leaching plant had been built at the Indooroopilly mine site in 1959, forming the first section of the mineral processing plant.

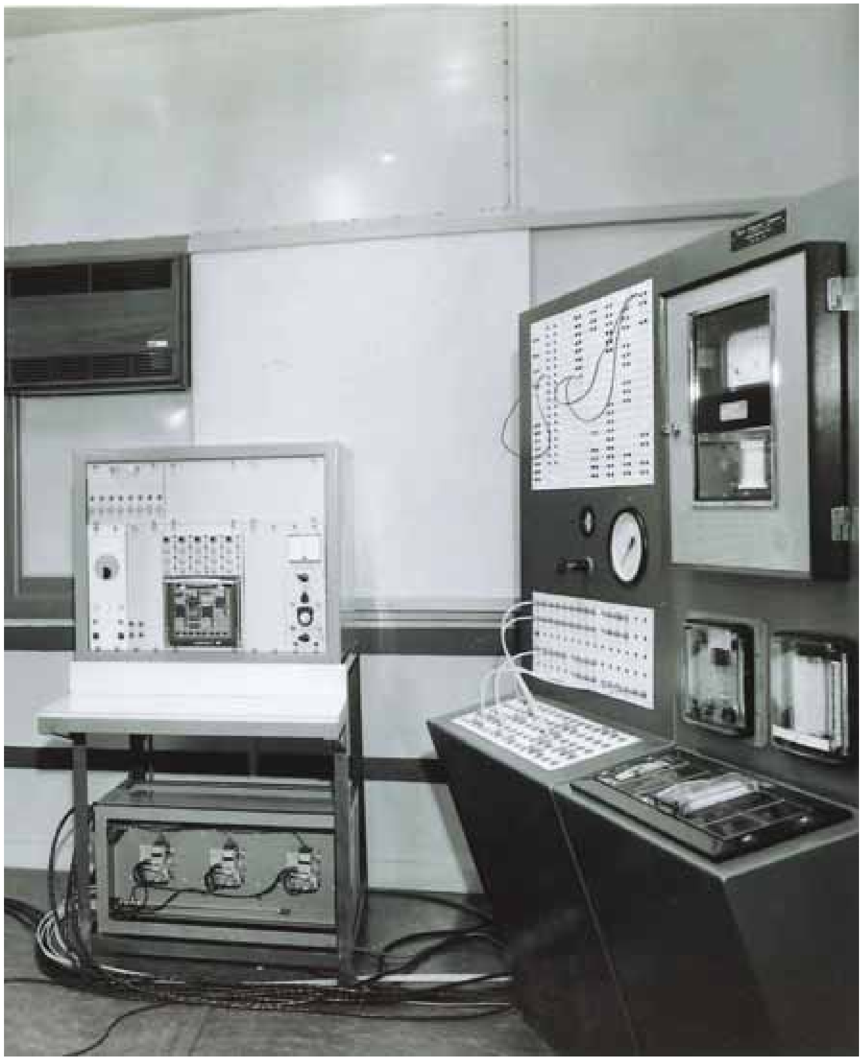
A three-year grant was received in 1962 from the Australian Mineral Industries Research Association (AMIRA) to develop automatic control systems for mineral grinding circuits, a project otherwise known as P9.

The advent of rapidly-advancing computer technology was timed perfectly, not only in the momentum needed to establish the JKMRC, but in respect to numerous other global factors.

By 1960 a dramatic shift had already taken place in computer hardware from vacuum tube components to solid state devices such as transistors and integrated circuit chips.



A US Army photo shows what computer components looked like in 1962



The former JKMRC Control Room

Benefits included lower costs, higher speeds, improved reliability and reduced power consumption.

Project P9 would ride the wave of transformation artfully.

There's a certain incongruity to the marriage of circuit boards with eons-old minerals extracted from the depths of the Earth, yet it proved a magical mix that would give birth to many subsequent research endeavours.

TECH HAZARDS OF THE ERA

In the early years, all computer work had to be performed at UQ's St Lucia campus. This was a tedious process at best, involving trips backwards and forwards from the Indooroopilly site.

First, the individual would need to travel to St Lucia to submit programs, in the form of punched cards, and then conduct another trip to collect the results, as turnaround was rarely rapid.

Even minor programming errors meant a failed run, plus a day or more lost to repeat the whole process.

The situation improved after the arrival of another computer at the pilot plant. Thereafter, simple programs could be run on this machine, provided it was not installed at a plant site.

Still, it was a long way short of today's technology, where such obstacles would be unthinkable!

WHITEN THE WHIZ

The computer wizardry behind the early breakthroughs of the JKMRC was largely the work of Bill Whiten.

He was a mathematician from New Zealand who had joined The University of Queensland's computer centre in its early days.

Dr Lynch and Whiten had become acquainted during the many visits to the computer centre and Lynch offered Whiten a job within his group at the beginning of 1966.

Whiten worked at the JKMRC for the next forty years and was critical to the success of the group

An expanded P9 proposal submitted for the years 1968-70 included the acquisition of a small digital computer – in capacity, if not size.

The computer was for use in process control trials in plants, and the start of flotation modelling research.

Students became proficient FORTRAN (a grammatical contraction of Formula Transition) programmers under the tutelage of Whiten. It was a programming language particularly suited to numeric and scientific computing.

During the latter part of the 1960s, Whiten developed software which transformed modelling practice.

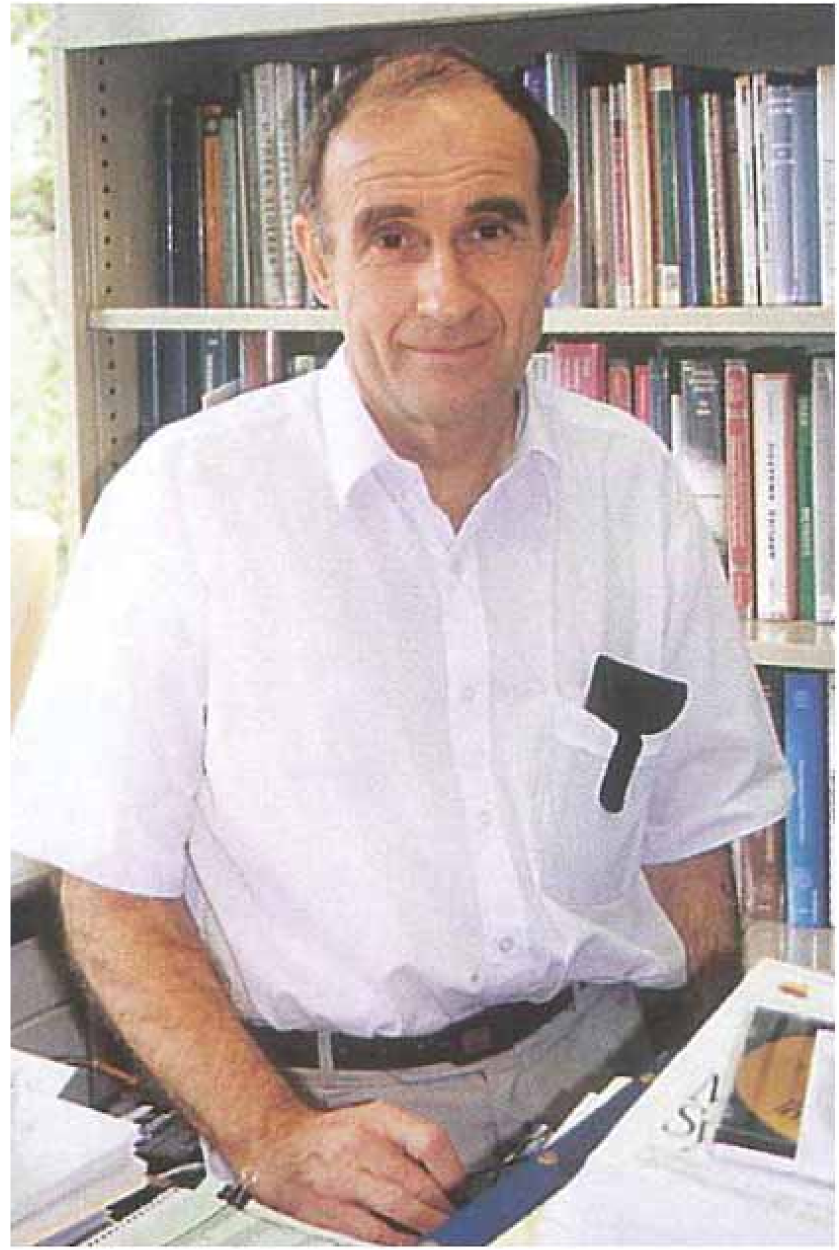
He wrote a suite of general purpose programs and subroutines suitable for most simulation tasks. This structure was universally used for the group's modelling work.

Whiten then turned his hand to the development of mathematical techniques for processing experimental data—mass balancing, curve fitting and model parameter estimation.

Displaying rare skill, Whiten combined his mathematical and programming skills to solve mathematical modelling problems inherent in the approach adopted by Lynch.

His contributions over decades became a consistent feature of the JKMRC story.

"It is often said that the biggest decision a tiny group makes is the appointment of the second staff member," former centre director Don McKee stated.



The late Bill Whiten was a pioneer of computing within the JKMRC


Don McKee, who was full of praise for Bill Whiten, also had a strong aptitude for computing in research

"Alban Lynch struck gold when he enticed Bill Whiten to join him at the pilot plant.

"Whiten was the key to the modelling, simulation and control developments from the mid-60s and to a host of subsequent advances.

"Whiten's mathematical and computing skills fitted the needs of the JKMRC perfectly.

"He was the first port of call when people ran into inevitable maths and programming problems, and a fantastic source of research ideas.

"Just as significantly, he was supervisor of 27 students and adviser to many more, a role he continued to provide into the 2010s, never really retiring from mentoring people.

"Whiten was essential to the JKMRC, it is as simple as that."

A KEY BREAKTHROUGH

Soft sensors are typically what we now call software that can measure data coming from a plant component and use that data to deduces its state of operation.

In 1967 Ken Dredge, a Mount Isa Mines instrument engineer, designed an analogue computer control system for one of the grinding circuits in the mine's concentrator.

An equation was derived from the cyclone model to predict product size – effectively a soft sensor – and a variable speed drive was installed on the cyclone feed pump to control sump level.

Control of ore feed rate was based on the predicted product size.

As a result, circuit stability improved and throughput increased. This was a major achievement and a vital contribution to the success of P9.

EXPANSION IN THE 1980s

The main feature of a new building for the JKMRC in 1982 was space for a new computer and a separate room hosting terminals which were linked to the computer.

This was to serve as the computing hub of the JKMRC for years to come, until the proliferation of personal computers.

The new computer was a PDP-11/44, considered a high-performance system for its time. It could have up to 4 megabytes of main memory.

It arrived as part of National Energy Research, Development and Demonstration Council (NERDDC) funding for the JKMRC blasting project.

Unsurprisingly, the layout and network were designed and installed by Bill Whiten, once more illustrating his central role to the technological underpinnings of the JKMRC.

WISEMAN COMETH

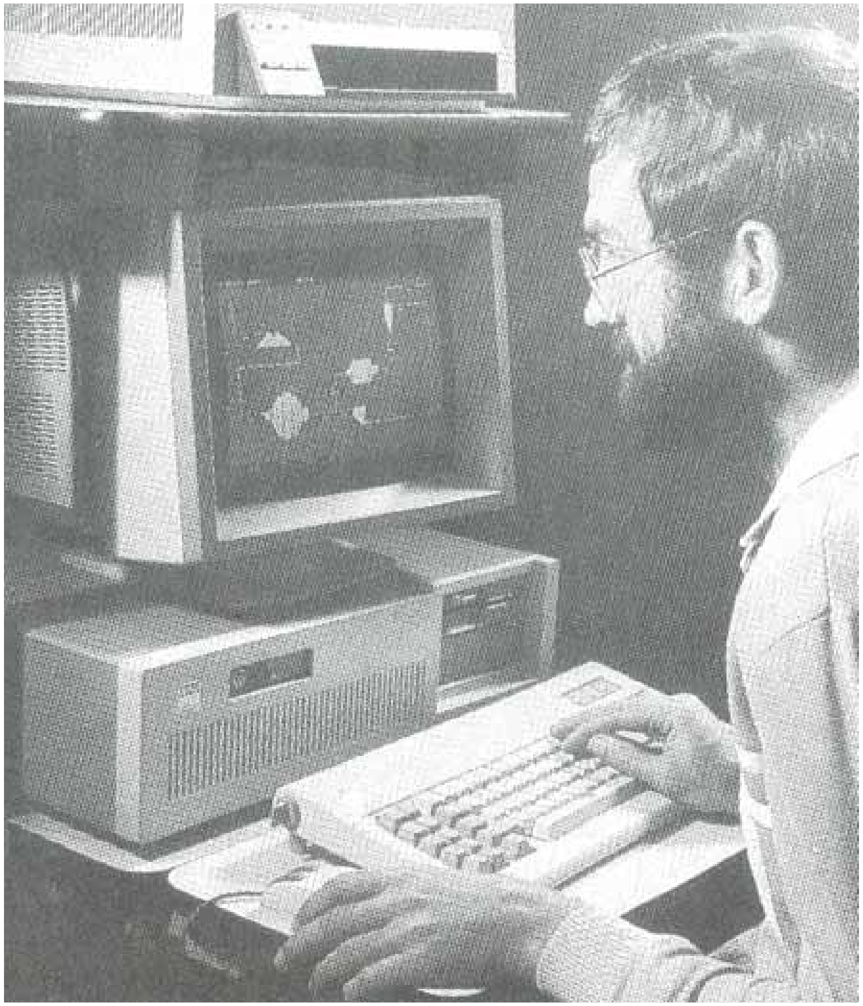
David Wiseman joined the Julius Kruttschnitt Mineral Research Centre as a student in 1983, having worked Mount Isa Mines and Hamersley Iron (now a subsidiary to Rio Tinto).

Wiseman embarked on a Masters project to develop a mineral processing simulator.

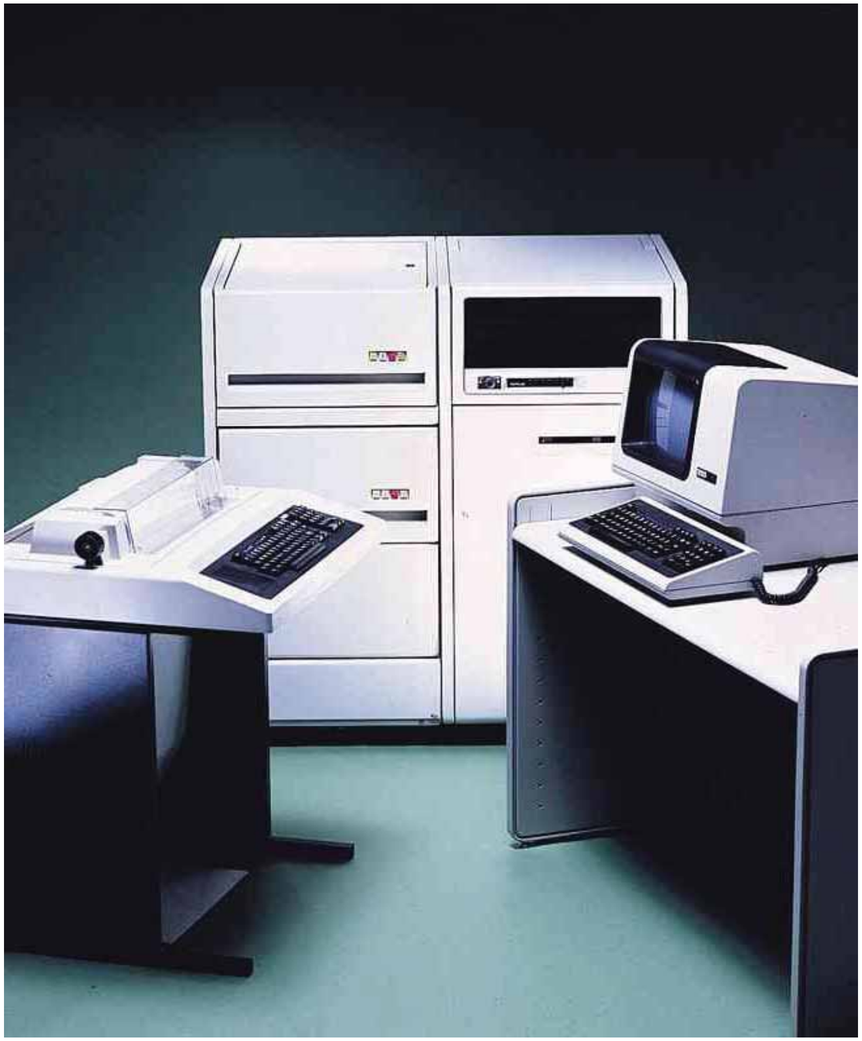
He had both an aptitude for computing and a commendable personal drive.

Together with Fred Hess, who had recently completed his PhD thesis, they went to work using a PDP-11 computer and a Hitachi PC for a colour terminal.

After a year of intensive work and development, the first version of the mineral processing simulator was ready to be introduced.



David Wiseman in an almost identical shot to Don McKee, working away behind the keyboard



The much-heralded PDP - 11 44

It was demonstrated to a meeting of North American sponsors in Los Angeles on the last Sunday in February 1984 where it was enthusiastically received.

This event did not go off without a hitch, however.

A fuse in the Hitachi monitor blew the day before the meeting and a small fortune was spent finding a technician to fix the problem.

But the positive response provided the impetus the centre needed to take the software on to a commercial version.

TECHNOLOGY OPENS WAY TO COMMERCIAL OUTCOMES

Even within anecdotes of the cost pressures which besieged the supremely resilient Julius Kruttschnitt in his earliest years in Australia, there were lessons to be found about the ruthless, challenging nature of making mineral extraction profitable.

The science of mining is one thing. The business of it is another.

However, it is true they are inextricably intertwined and, without one, there would not be need for the other.

Throughout its existence, the JKMRC has arguably recognised and valued the importance of achieving strong financial returns.

Part of that has been due to the centre's extremely strong ties to industry, where commercial imperatives were naturally front-of-mind.

To achieve status as an ongoing concern, in an industry of such high stakes, making a profound commercial impact had to be a key goal of the JKMRC.

JKTECH

If one were to list the moments which defined and transformed the Julius Kruttschnitt Mineral Research Centre, then the birth of commercialisation company JKTech in 1985 would be near the top..

JKTech became the vehicle for transferring research breakthroughs and new technologies into commercialised opportunities.

As is the case with academia since time immemorial, those who pursue the greatest research advancements are typically focused on the task at hand, and not always the best at monetising their discoveries.

JKTech signalled the availability of a dedicated group of people who could turn research into products, and sustain further projects into the future.

BAILEY'S PLACE IN HISTORY

The first full-time staff member employed by JKTech was Chris Bailey.

Previously, a UQ graduate in metallurgy, with honours in flotation modelling, he as also one of the early administrators of the JKMRC, and was described as "unflappable" by those who encountered him.

Bailey managed the centre's finances and was regularly sought-out for advice on monetary matters.

Medical issues had seen Bailey diverted away from the 'coalface' (excuse the malapropism) at Broken Hill's Zinc Corporation.

Discovering Bailey had an impressive brain for numbers and dollars, Alban Lynch persuaded him to extend his work beyond research and consulting to include administration and finance.

Bailey was considered indispensable and was essential to the centre remaining self-funding and able to meet the development cost of new projects, with expenses always tightly controlled.

JKTech
JKMRC
Commercial Division

Minimum Computer Requirements for JKSimMet

Option A

IBM PC AT or fully compatible computer with
- 640 Kbyte memory minimum, and
- 1.2 Mbyte (5.25 inch) diskette drive or 720 Kbyte (3.5 inch) diskette drive, and
- 20 Mbyte or larger fixed disk drive, and
- 80287 Maths Co-processor, and

either
- IBM EGA, VGA or fully compatible equivalent and
- a suitable monitor, and
- HALO 88 graphics package license for RM Fortran (available from JKTech),

or
- IBM Professional Graphics Controller (PGC) or fully compatible equivalent, and
- IBM Professional Graphics Display or NEC Multisync Monitor, or equivalent,

Option B

IBM PS/2 Models 50, 60, 70 or 80
- 640 Kbyte memory minimum, and
- 1.2 Mbyte (5.25 inch) diskette drive or 720 Kbyte (3.5 inch) diskette drive, and
- 20 Mbyte or larger fixed disk drive, and
- 80287 Maths Co-processor, and
- IBM EGA, VGA or fully compatible equivalent, and
- a suitable monitor, and
- HALO 88 graphics package license for RM Fortran (available from JKTech),

and

a Monochrome printer from the list below
- IBM Proprinter
- Epson MX80 or LX-800
- DEC LA Series
- NEC Pinwriter
- HP PCL

or any printer which will fully emulate any of these

and
- IBM PC DOS 3.1 or MS DOS 3.1 or more recent versions

in addition

The following optional equipment considerably enhances the operation of JKSimMet.
- Microsoft Mouse or functional equivalent

System Selection

A. If the system is to be dedicated to JKSimMet use, considerable speed advantage is provided by the PGC option. A number of these is available in addition to the IBM controller. The ones JKTech have tested are
- Everex EPGA from Everex Systems Inc.
- Image Manager 640 from Vermont Microsystems

B. If the system is to be used for a variety of applications including JKSimMet, then the flexibility of a VGA (plus Halo) system is recommended. The HALO 88 driven system has been successfully tested with a range of EGA and VGA cards. Any reasonably close clone of the IBM standards should support JKSimMet. This option can be run most effectively using additional memory configured as a Ram Disk.

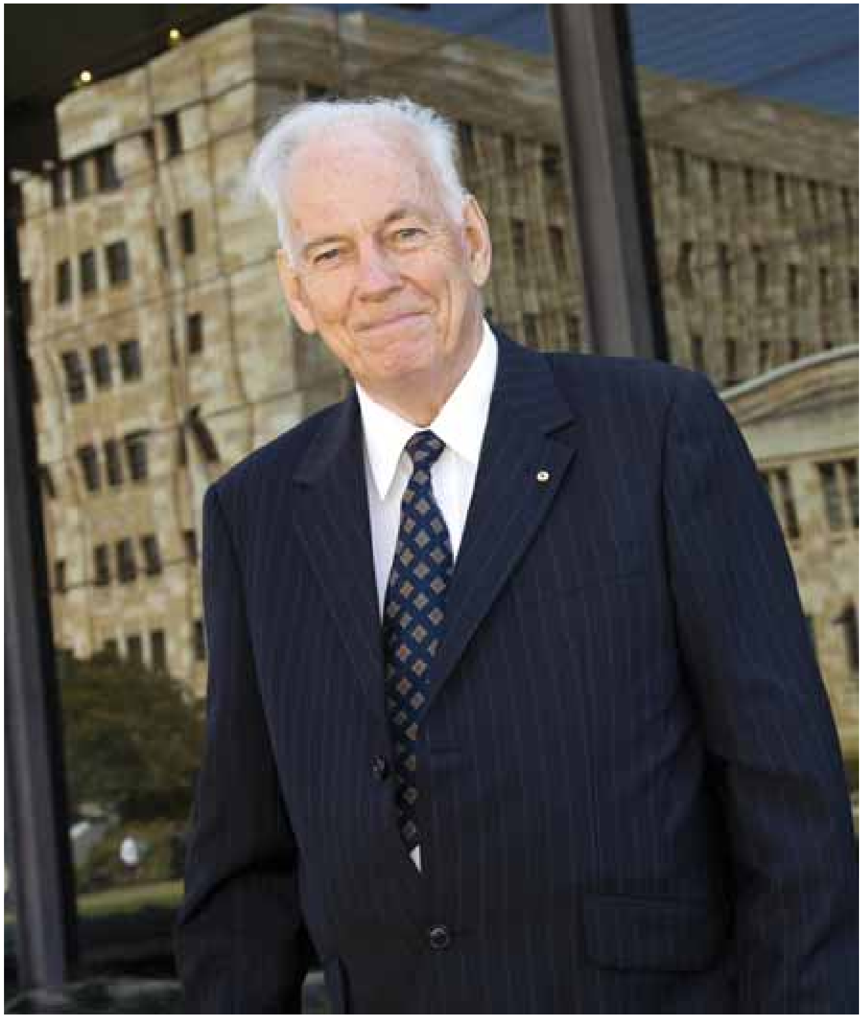
Equipment Tested

A wide range of equipment combinations has been successfully tested but if you are in doubt JKTech will be pleased to supply a system checkout disk so you can test a particular combination.

Hardware Supply

JKTech can supply a complete computer system with JKSimMet already installed and ready to use.

An early JKTech tech spec complete with fax number



The late Emeritus Professor Brian Wilson

UNIQUEST

When new UQ Vice-Chancellor Professor Brian Wilson took his position in 1979, he brought a new approach to exploring the commercial potential of research by tertiary institutions.

"Professor Wilson made early inroads into exploring alternate sources of income for the University, the benefits of which are still felt today," remarked Professor Aidan Byrne in 2019.

"He saw the potential of commercialising research outcomes to solve industry problems, while also securing UQ's financial independence.

"His vision led to the establishment of UniQuest in 1984. It is now Australia's foremost University commercialisation entity."

To his eternal credit, Professor Wilson was very open to listening about the thoughts of the JKMRC, which by that stage already collected the main ingredients needed for its own commercialisation arm in JKTech.

The ingredients were: strong connections to industry, the development of a mineral processing simulator, and the energy and optimism to seek out new ventures.

In addition, there was a ripe market for consultation. Many of the resources for the P9 project had been directed at consulting, rather than solely research-type studies for sponsors.

A TIPPING POINT

The critical moment had occurred when Don McKee joined a team in the Queensland Enterprise Workshop Program in 1984, with the goal of developing a business plan for commercialising the simulator software.

In retrospect, it was an unlikely, disparate group which wrote a business plan that would win the Workshop state and national competitions.

The group consisted of an arts graduate, a natural therapist, a commerce graduate who owned a milk run, together with a graphic artist.

A revised plan was put before the JKMRC Policy Committee, describing in careful detail how a commercial venture to sell the simulator and provide consulting services, would work within the structure of the centre.

Acceptance and approval by the P9 project sponsors, AMIRA, was crucial.

As it eventuated the AMIRA board was convinced that the advent of commercial activity would not compromise the robust professional ethics of the JKMRC.

MARKET SUCCESS

To kick-start JKTech's life, the Julius Kruttschnitt Mineral Research Centre provided a loan of $100,000.

In a sign of its success, JKTech repaid the amount in the space of 18 months.

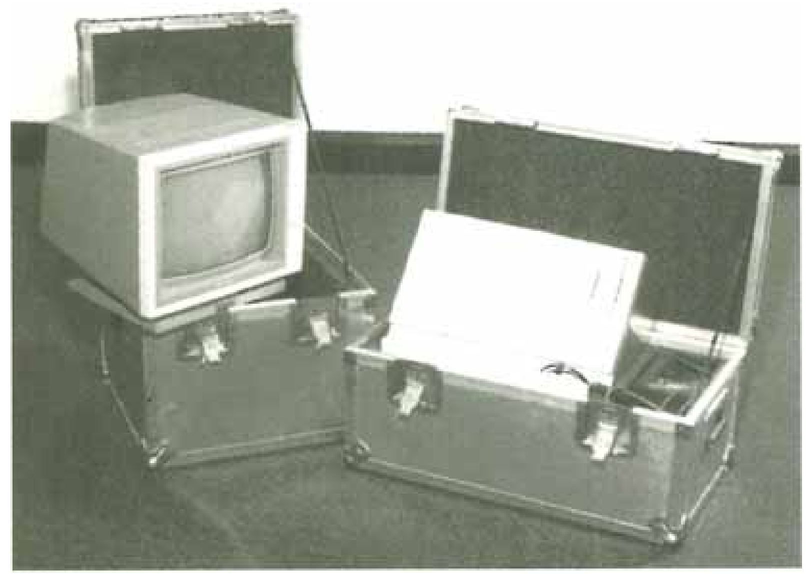
Indeed, JKTech found its feet quickly, demonstrating there was a market for its software products and consulting services.

The name JKTech became synonymous with innovation and excellence. By the end of the decade JKTech had an income of almost $1m and the number of technical staff rose from 2 to 12.

New and expanded facilities were demanded and agreed to, with a new JKTech building opened in 1986 – a risky commitment for such a young venture.

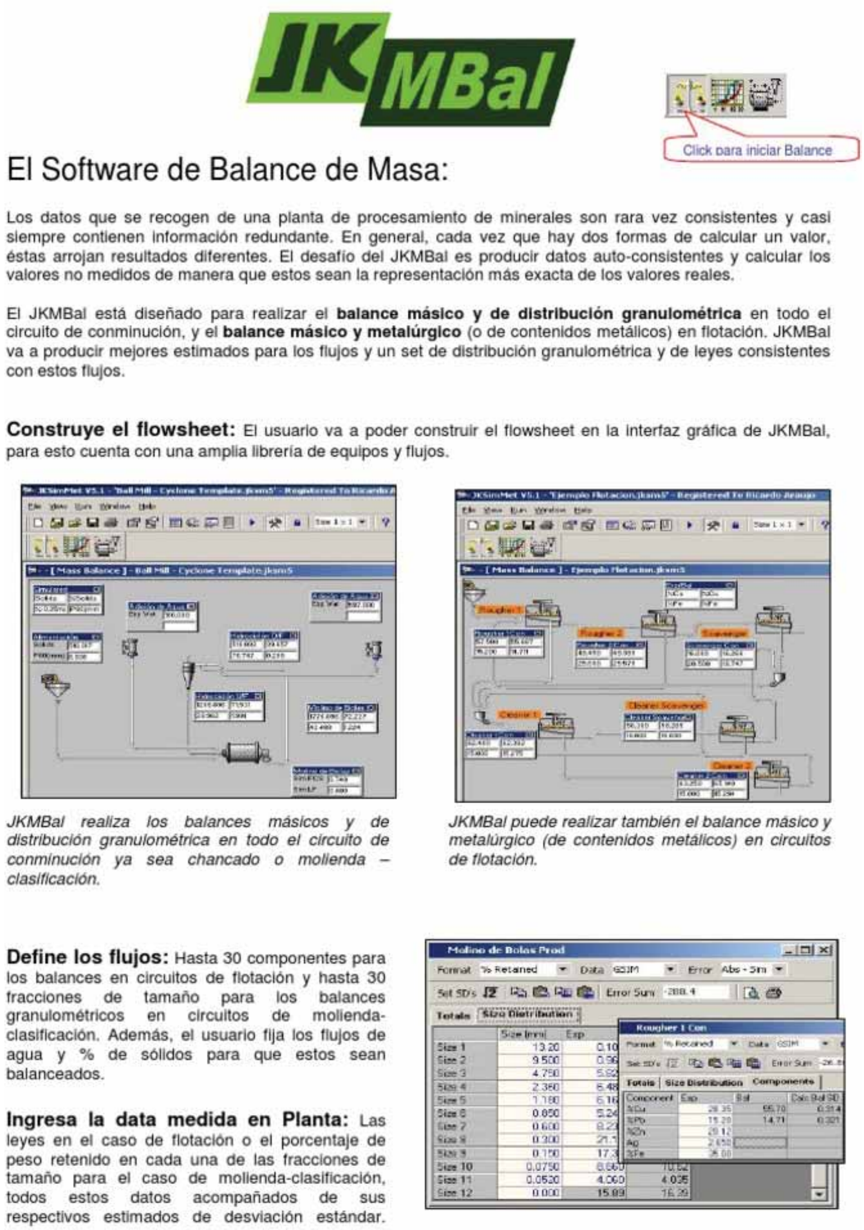
The initial challenge was to produce a commercial standard version of the prototype system for analysis of comminution and classification circuits that had been completed in 1984 within P9.

By 1986 a new version named JKSimMet was ready for testing in the field and by 1987 JKSimMet was ready for commercial sale.



Early version of JKSimMet being unloaded from trunks, ready to operate

Steve Morrell, Chris Bailey, Rob Morrison, Bill Whiten and Dave Wiseman won an AusIMM award in 1993 for the development of JKSimMet



JKMBal

Click para iniciar Balance

El Software de Balance de Masa:

Los datos que se recogen de una planta de procesamiento de minerales son rara vez consistentes y casi siempre contienen información redundante. En general, cada vez que hay dos formas de calcular un valor, éstas arrojan resultados diferentes. El desafío del JKMBal es producir datos auto-consistentes y calcular los valores no medidos de manera que estos sean la representación más exacta de los valores reales.

El JKMBal está diseñado para realizar el **balance másico y de distribución granulométrica** en todo el circuito de conminución, y el **balance másico y metalúrgico** (o de contenidos metálicos) en flotación. JKMBal va a producir mejores estimados para los flujos y un set de distribución granulométrica y de leyes consistentes con estos flujos.

Construye el flowsheet: El usuario va a poder construir el flowsheet en la interfaz gráfica de JKMBal, para esto cuenta con una amplia librería de equipos y flujos.

JKMBal realiza los balances másicos y de distribución granulométrica en todo el circuito de conminución ya sea chancado o molienda – clasificación.

JKMBal puede realizar también el balance másico y metalúrgico (de contenidos metálicos) en circuitos de flotación.

Define los flujos: Hasta 30 componentes para los balances en circuitos de flotación y hasta 30 fracciones de tamaño para los balances granulométricos en circuitos de molienda-clasificación. Además, el usuario fija los flujos de agua y % de sólidos para que estos sean balanceados.

Ingresa la data medida en Planta: Las leyes en el caso de flotación o el porcentaje de peso retenido en cada una de las fracciones de tamaño para el caso de molienda-clasificación, todos estos datos acompañados de sus respectivos estimados de desviación estándar.

JKMBal brochure in Spanish

JKSimMet, which made simulation possible within the wider industry, was still being sold at the time of publication, more than 30 years after its release.

Indeed, JKSimMet sold strongly for a niche product of such complexity, and overseas agencies were put in place — the most important, successful and long lasting was with Mark Richardson in the USA.

Courses in JKSimMet and in comminution simulation and modelling were presented within Australia and in the USA.

JKMBal, a mass balancing system, was completed and put to market. Mass balancing is a tricky exercise which provides accounting of the materials entering and leaving a system, and enables better understanding of flowrates within a system, as well as assessing the quality of data obtained from sampling and surveys. Much of the 'smarts' behind the mass balancing algorithms were developed at the JKMRC, with major contributions from Steven Gay, one of the centre's key mathematicians of the era. JKMBal made the mass balancing process much easier to conduct with confidence through a software tool.

Above all, it had been demonstrated that JKMRC research and JKTech could successfully co-exist within the centre, and that the industry accepted the new arrangement.

MAN OF MANY TALENTS

Back on the theme of technological advances, Alan Cocker proved to have a rare ability to develop software.

Cocker initially joined the Julius Kruttschnitt Mineral Research Centre in 1988, and was initially heralded as a petroleum geologist, though that description alone cloaked his many talents.

His software played a pivotal role in converting research developments into utilities for the mining industry – particularly in the field of coal operations.

"Throughout his 18 years at the JKMRC, he was an unflappable character who rode the ups and downs and got on with the job," remarked former colleague Don McKee.

Others to have an impact around the same time included Kai Riihioja, a physicist who spent many years converting blasting models into usable form.

Shortly thereafter, Mehmet Docktan (ACARP projects), Darren Thornton (instrument development), Sarma Kanchibotla (explosives) and Bob Trueman (the caving project) joined the group.

WHITEN'S DISCIPLES

As time went on, Bill Whiten's influence was such that he ushered in a new generation who adopted his knack for solving problems with a combination of mathematics and technological innovation.

Toni Kojovic was first in what was informally termed 'Whiten's mathematics group', which expanded to a student body concerned with modelling techniques and new process control methods. After a long association with the JKMRC that started in 1984, Kojovic later became the Principal Consultant with JKTech from 2003-13.

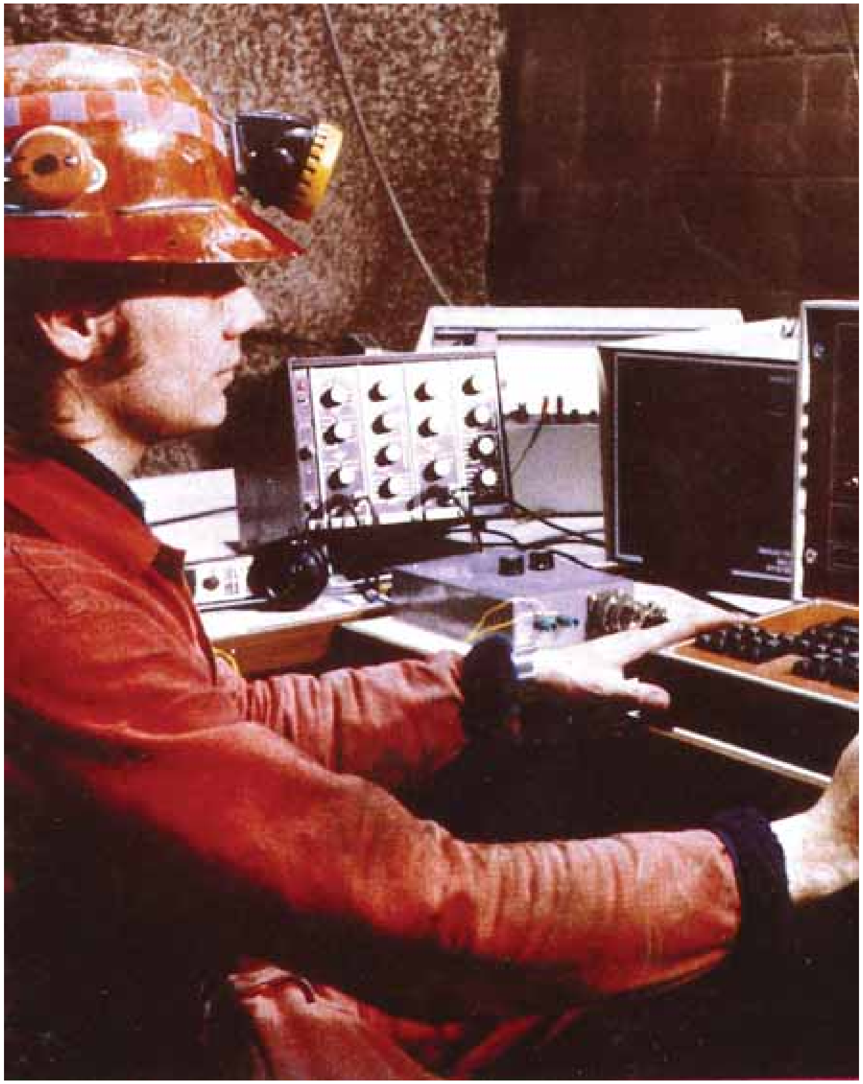
David Ginsberg and Ladislav Kocis were fellow Whiten disciples whohelped introduce a range of data analysis developments in the late 1980s and early 1990s.

Just as in the 1960s, when Whiten had made a profound impact with his simulation programs, further Whiten-inspired techniques found their way into wider JKMRC research many decades later.

Glen Corder with Rob Morrison

MORE STRINGS TO THE BOW

A steady stream of new consulting areas and products flowed from the JKMRC in the 1990s.



With every year computer equipment in mining environments became more commonplace

Process control consulting began with Glen Corder and Rob Morrison. Then the following year Phil Guerney brought hydrometallurgy skills.

Mike Higgins, a mining engineer, joined JKTech to develop blasting software to commercial standards.

In the years that followed, Chris Wood transferred from the JKMRC coal preparation group to develop coal capabilities within JKTech, Dean David brought across his processing skills, and Peter Cameron came aboard to lead product sales in 1998.

Others who had been with the centre for a long time also repositioned themselves slightly, and the centre evolved organically in its structure, just as it had done over preceding decades.

The 1990s were remarkable for the number of research developments which were developed into products by JKTech. While not all had large markets or were ultimately successful, there was a powerful drive within the centre towards commercialisation.

Virtually every year a new product was released.

By this stage research project sponsors had an expectation that outcomes with commercial potential would be successfully delivered by JKTech.

INTO A NEW MILENNIUM

The first decade of the 2000s saw software development sustain its importance to the reputation and renown of the JKMRC.

Ongoing updates to JKSimMet and JKSimFloat (now the global industry standard in simulation of flotation plant operations which enables users to optimise throughput, grade and recovery), the MLA (an automated mineral analysis system for identifying minerals and quantifying a wide range of mineral characteristics) and new products such as JKMetAccount (software for tracking the movement of metal and mineral products through mining, enrichment, refining and distribution) certainly kept the centre busy and front-of-mind in the industry.

Outside of the software development leads – Ying Gu and later Bob Lasker – there were three people who firmed the glue of JKTech.

One was Chris Bailey, an expert in comminution and the longest-serving staff member.

Another was Joan Richardson, who had provided all administrative functions and also been present since virtually day one.

The third was Debbie Gray, who joined Richardson in the early days when the workload became too large for even the tireless Richardson to handle.

REVENUE DOUBLED

Annual income from JKMRC research and the affiliated JKTech jumped from $4.4 million to $10 million per annum during the 1990s.

In 1991 the 100th JKSimMet licence was sold, with many going overseas. The success of JKSimMet showed that software could be effectively commercialised and marketed in Australia and overseas, and demonstrated that research and commercial activity could co-exist within the same castle.

Just as impressively – and impactfuly – staff and student numbers rose from around 70 to over 130 in a similar period.

To further underpin the success of the centre, all this had been achieved amidst the departure of founding figure Dr Alban Lynch and a transition to new leadership.

The strong and effective relationships forged over many years between senior personnel Don McKee, Tim Napier-Munn, Andrew Scott, Rob Morrison and Lindsay Fell played a major role in this smooth transition.

JKSimMet slideshow presentation used to induct new users

Just as with computers, electron microscopes jumped ahead in leaps and bounds from this 1960s model in the UQ museum

JKTech was working as was originally envisaged, with the research and commercial areas developing effective ways to work together.

Both areas had exceedingly capable and experienced people with a shared commitment to ensure the centre was a continuing success. In many cases JKMRC personnel transitioned to JKTech, maintaining a continuance between academic and commercialisation endeavours.

Above all, the JKTech concept worked because the industry and AMIRA were supportive, the leadership within the JKMRC embraced the concept and JKTech displayed the capacity to produce commercial standard products and successfully market, sell and support the products.

Both the industry and the JKMRC were winners.

UNDER THE MICROSCOPE

Ian McKinnon, head of electron microscopy at The University of Queensland, had excellent contacts within the ranks of microscope suppliers.

Along with Don McKee and Tim Napier-Munn, McKinnon convinced Philips Electro Optics in the Netherlands to supply a scanning electron microscope (SEM) to the JKMRC at no cost.

Quite logically, the JKMRC team argued that there was significant commercial potential for a new SEM-based analyser, which would pave the way for Philips to increase their sales of microscopes.

The innovation they planned had the potential to fundamentally change the way mineralogy studies were used for more efficient mineral separation.

Once Philips were convinced, there were two more steps necessary to get the project up and running.

Importantly, the JKMRC had to find the funding for the intensive software development that was required. Professor Paul Greenfield, Deputy Vice-Chancellor (Research) at the time agreed to fund a significant part of the costs.

Finally, there was a need for someone with the skills to do the job. Good luck smiled with the appointment of Dr Ying Gu (also see *Diversity at the Core* chapter) to tackle the project, a mineralogist who had previously worked with the CSIRO and Western Mining Corporation on similar projects. This initiative would lead to the development of the JKMRC mineralogy laboratory, and the Mineral Liberation Analyser, or MLA, technology, which would be eventually adopted at a global scale. But more on that later.

INTO THE 2000s

The JKMRC Annual Report for 2000 opened with a photo of a pair of native Boobook owls who roosted on a drainpipe underneath a busy walkway between two buildings at the Indooroopilly mine site.

Quite humorously, the report quipped the owls were famed for 'benevolently bestowing their wisdom, and occasionally other contributions', on those passing beneath.

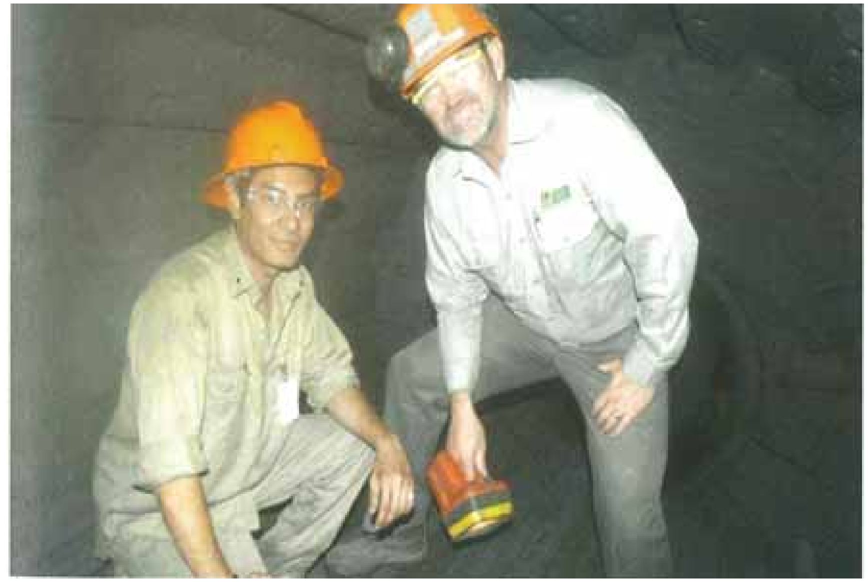
The JKMRC began the new millennium with a corporate professionalism that built off the back of the more creative decision-making style in the centre's younger years.

The centre was working to a five-year strategic plan and it had a more formalised Advisory Board

The centre continued its research endeavours, driven by high achieving postgraduate students, and it maintained a strong international reputation for excellence and collaboration.

JKTech was about to become a fully independent company — no longer under the direct control of the JKMRC.

However, the annual report gave an insight to the tightknit collegial atmosphere, proudly showcasing the achievements of students, researchers, and technical and administrative staff.



Chris Bailey on site at Mount Isa Mines

The JKTech board of 2005

The late Emeritus Professor John Hay AC

Tim Napier-Munn acknowledged the postgraduate students 'who provide so much energy and talent to the core business of developing new knowledge.'

This was still the JKMRC that staff and students described as a family – a home from home, with like-minded people who were deeply interested in their work.

DOUBLE IMPACT

Two developments in 2001 were to have profound impacts on the JKMRC, although the full effects were not felt until the next decade.

The first was the establishment of JKTech Pty Ltd as a wholly owned company of UQ Holdings, the University entity established to put order into the commercialisation activities of the University.

JKTech had never received any capital injection from The University of Queensland and that did not change under the UQ Holdings arrangement.

From inception, JKTech had managed to finance its growth through earnings and the University saw no reason to change this.

JKTech was no longer responsible to the JKMRC Director, but now to a board of directors appointed by UQ Holdings.

The second important event in 2001 was the establishment of the Sustainable Minerals Institute (SMI) within the University.

Since his arrival as Vice-Chancellor in 1996, Professor John Hay had been campaigning to expand the research profile and performance of the University. In doing so, he built on foundations established by his predecessor, Professor Brian Wilson.

What emerged from Hay's drive were a number of well-resourced, high-profile research institutes, separate from the faculties.

The Vice-Chancellor attracted very large funding amounts from Chuck Feeney, a philanthropist committed to supporting medical type research, and also from the State Government when Peter Beattie, was the Premier of Queensland.

ATTACHING TECH TO MINE-TO-MILL METHODOLOGY

Comminution is the action of reducing a material, particularly a mineral ore, to minute particles or fragments.

Typically, due to the sheer physical effort involved in the process, comminution is the bottleneck in the mineral processing timeline that slows down all subsequent processing times, leading to inefficiencies and losses of time and money through various means.

Substantial savings can be achieved by using blasting to break rock, rather than the slower approach of mechanical grinding.

A preference for blasting came to the fore during the downturn of commodity prices in the 1990s, when margins for profit and error were reduced, while pressures for delivery were increased.

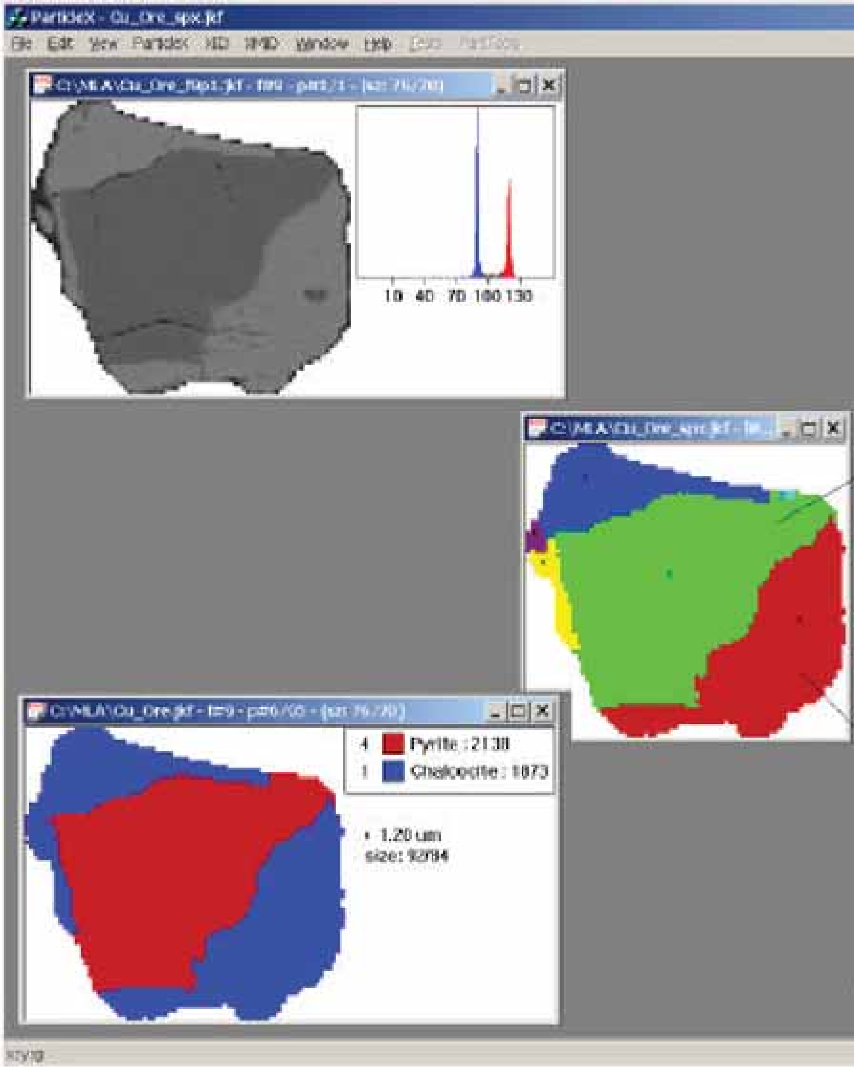
JKTech consulted on so-called 'mine-to-mill' methodology at the height of its importance, built off the back of JKMRC research on topic in this era, which formally connected blasting and comminution analysis and optimisation into a combined art.

Increased consultation on the benefits of flotation methods also occurred.

New versions of the software JKSimMet were released, as well as JKMetAccount, derived from the AMIRA metallurgical accounting project.

JKSimBlast became a very successful product, while JKFrothCam was also selling well. Furthermore, JKJigScan was installed in Australian and South African coal and iron ore operations.

Installation of JKFrothCam



MLA area x-ray analysis of a composite particle

JKTech had its fingerprints everywhere and part of its success was due to a disciplined approach to product development, meaning all potential products were rigorously assessed before proceeding to final development.

Looking back, it is clear that the JKMRC-JKTech association was working extremely well, just as envisaged 20 years before, when the bold decision was taken to form a commercial unit within the centre.

ASTONISHING NUMBERS

The growth in JKTech in the second half of the 1990s was remarkable.

In 2004, JKTech achieved revenue of \$5.6m and a profit of \$200,000. Overseas business surged and, by 2008, 70 per cent of \$14.3m total income was earned internationally.

By 2009, revenue was \$15.6m with a profit of \$2 m.

The growth was built on frequent consulting activity, continued strong sales of the flagship JKSimMet and JKSimFloat products, and new activities, many linked to the Mineral Liberation Analyser.

Under the leadership of Geoff Gault and later Dan Alexander, the JKTech Board chaired by Barry Kelly, embarked on the sale of IP to external parties during this period. The first was the sale of JKMetAccount to Mincom in 2006. The software was a good fit with Mincom's suite of products and services.

OPPORTUNITY FROM OVERLOAD

The demands on JKTech to maintain seven different Mineral Liberation Analyser (MLA) systems were putting a pronounced strain on space and resources.

In 2007, JKTech established a joint venture company, ALS Mineralogy, with Australian Laboratory Services (ALS) to take over the JKMineralogy business. Eugene Lowens, who had been managing the activity within JKTech, and support staff went to the new company.

Mineralogy acquired five of the MLAs, with two retained for JKMRC and other JKTech work.

The largest sale of all came when the MLA IP was sold to the FEI Company, accounting for most of JKTech's previously cited profit of $2m.

When JKTech acquired its first SEM (scanning electron microscope) system in 1996, it was supplied by Phillips Electron Optics. This Phillips activity was progressively acquired by FEI from 1997.

Phillips, and then FEI, had done very well through their association with JKTech and the MLA, with over 70 SEMs delivered worldwide.

It had been a great partnership, with JKTech supplying the MLA software. After protracted negotiations, FEI acquired both the MLA IP and Intellection in 2009.

Despite selling the MLA IP to FEI, JKMRC retained MLA capability and still operates three MLA machines under the oversight of the very experienced Elaine Wightman. This provides JKMRC researchers and industry partners access to the mineralogy analysis technology, as well as the process mineralogy expertise that has been maintained in JKMRC research.

CELEBRATING A MILESTONE

The year 2012 marked the 25th anniversary of JKTech, an occasion celebrated with a large and joyous dinner in Brisbane.

There was a lot to celebrate. JKTech had survived its early years which often claimed hopeful start-ups, had grown a business without relying on capital investment from The University of Queensland.

Furthermore, it had transformed many JKMRC developments into commercial standard products and services.

It had returned funds to both and centre and the University, proving that research and commercial activities could co-exist successfully.

JKTech 25 years dinner celebrations

JKTech 25 years dinner celebrations

Professor Neville Plint slotting into Queensland life in a Maroons polo

JKTECH & JKMRC AS ONE AGAIN

In 2020 both JKTech and JKMRC came under the one management structure, further solidifying their symbiotic relationship.

Sustainable Minerals Institute Director Professor Neville Plint was appointed Managing Director of JKTech, in addition to his role with SMI.

Professor Plint said the move consolidated and strengthened the consulting and research functions of both organisations and enhanced the testing and product delivery to clients.

"SMI's goal is to provide solutions to the significant challenges facing the resources sector," he said.

"Bringing together the teams in JKTech and JKMRC helps us drive innovation and continue to provide mining and metallurgy research and consulting services worldwide."

Though teams in both organisations maintained a close working relationship since JKTech was established in 1986, the announcement saw a return to a singular path forward, while simultaneously preserving JKTech's corporate and technical identity.

Under the new structure, Professor Plint was supported by a management team comprising Professor Rick Valenta (Director, JKMRC), Paul Napier (Chief Financial Officer, JKTech), Bevin Wong (Operations Manager, JKTech) and Associate Professor Marcin Ziemski, who took on the role of commercial lead working across JKTech and JKMRC.

CHAPTER 4

BIG, BOLD BREAKTHROUGHS

AN AMBITIOUS PROPOSAL

JKMRC's initial funding proposal to AMIRA in 1961 was extremely ambitious and envisaged modelling and control of both grinding and flotation circuits.

The wise people in the industry who responded to the proposal recognised that flotation would be a step too far and restricted the project to a study of grinding. Hindsight proved this to be the correct response. Indeed, the project did not begin work on flotation until the second three-year extension in 1968.

Thirteen companies agreed to fund the project: BHP, Broken Hill South, Cement and Concrete Association of Australia, CRA, Electrolytic Zinc, Mary Kathleen Uranium, MIM, Nairne Pyrites, North Broken Hill, Peko Mines, Territory Enterprises, United Uranium and Western Mining Corporation. Later, King Island Scheelite, Aberfoyle and Mount Lyell joined.

Almost all these companies have since disappeared, although some exist in a different form and still support the project.

It was clear from the response that Lynch had outlined an imaginative and highly relevant project. AMIRA funding was guaranteed for three years at £3000 per annum.

Interestingly, the larger companies paid a higher contribution than the smaller ones.

The AMIRA model of research had many advantages. Firstly, companies were not obliged to support a particular project. Each judged a proposal on its merits and on its relevance to its own operations and interests.

Don McKee, Bruce Fraser, Tim Napier-Munn, David Nairn, Alban Lynch, Jim May, Richard Beck, David Stribley, Steve Morrell, Emmy Manlapig

Researchers involved in AMIRA P9 gather to celebrate 50 years of the project in 2011

AMIRA more recently held its own celebrations in 2019 to celebrate 60 years as an entity

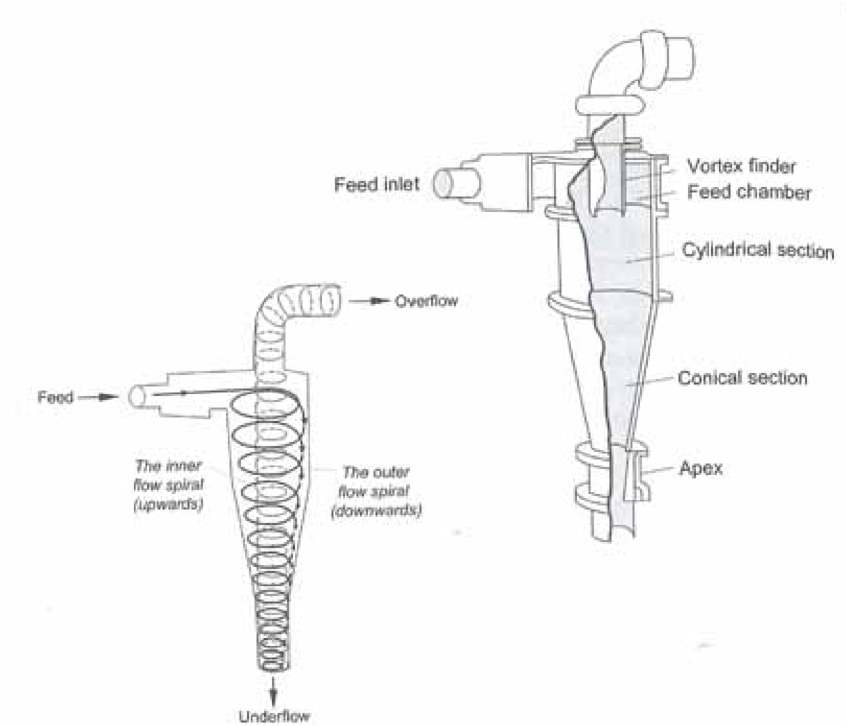


Diagram of how hydrocyclones work from the book Mineral Comminution Circuits by Tim Napier-Munn

Secondly, the costs were shared, which was undoubtedly an attractive feature. Thirdly, and probably most importantly, the results of the research were shared equally amongst the sponsors. This model of sharing is still a feature of many minerals industry research projects.

The objectives of this first project were the development of mathematical models of mineral grinding circuits for simulation, optimization and control.

From his work at Broken Hill, Lynch understood just how access to a digital computer could enhance the development of models and simulation.

The time was right to take a brave leap into the future.

DAWN OF THE HYDROCYCLONES

In the early 1960s, hydrocyclones were installed in comminution circuits world-wide to replace rake and spiral classifers in grinding circuits. The role of the hydrocyclone in the circuit is to work out which particles are ground up enough to pass on to the next processing stage and which ones need more grinding.

The P9 project needed to develop a suitable mathematical model of a cyclone – without it, grinding circuit modelling was impossible.

Hydrocyclones are deceptively simple machines, but many operators had difficulty when they first introduced them into circuits. Mount Isa Mines (MIM) built a test rig, but no metallurgist wanted to work on the problem.

Early researcher Tadimety Chakrapani Rao (also known as TC Rao, covered in greater detail in the *Diversity At The Core* chapter) soon found himself living in the MIM company barracks. Lynch accompanied him for long periods, and the two men got to work in the painstaking measurement of circuits on site in a hot, remote plant, then taking data back to Brisbane for study.

Lynch told Rao: “The cyclone is yours.”

"They got the job done," Lynch said. "In fact, they did it twice – there was a problem with an instrument measuring the flow rate to the cyclone. So, Rao went through it all again."

The first breakthrough came after just 18 months – a new cyclone model devised by Rao. Six months later, after two years of experimental work by Lynch and Rao, new grinding models had been produced. The cyclone model made circuit simulation possible.

AN EXTENSION & PROCESS CONTROL STUDIES

Successes, both technical and in project methodology, were enough to impress AMIRA which, in late 1964, renewed support for a three-year extension of P9 with increased funding.

Impressed by the hard work of Lynch and Rao in the plant, MIM agreed to pay Lynch's salary and provide a grant for equipment. For the first time, the 1965-67 project would embark on process control studies in plants.

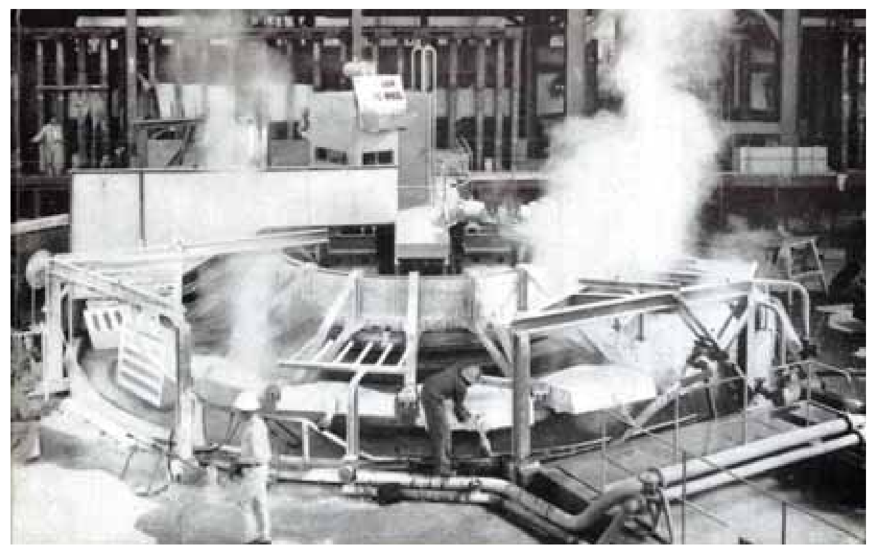
The pattern was set—postgraduate students spent months at remote plants collecting data for thesis projects. It all looked disarmingly basic. But this unassuming project would astound the research community with its achievements, and with its longevity.

P9 has continued for approaching 60 years at the time of print, and its early success formed the basis of what would become the JKMRC on the site of the University mine in Indooroopilly.

In those first hard-working decades Lynch said he had one enormous advantage.

"They were years when mining companies were led not by lawyers and accountants, but by mining engineers, geologists and metallurgists who knew their business. They could see that nothing much had been done in developing equipment for years because of the depression and the war," he said.

Historic photo of Mount Isa from the book Mines in the Spinifex by Geoffrey Blainey



A look inside Mount Isa Mines from the Geoffrey Blainey book Mines in the Spinifex

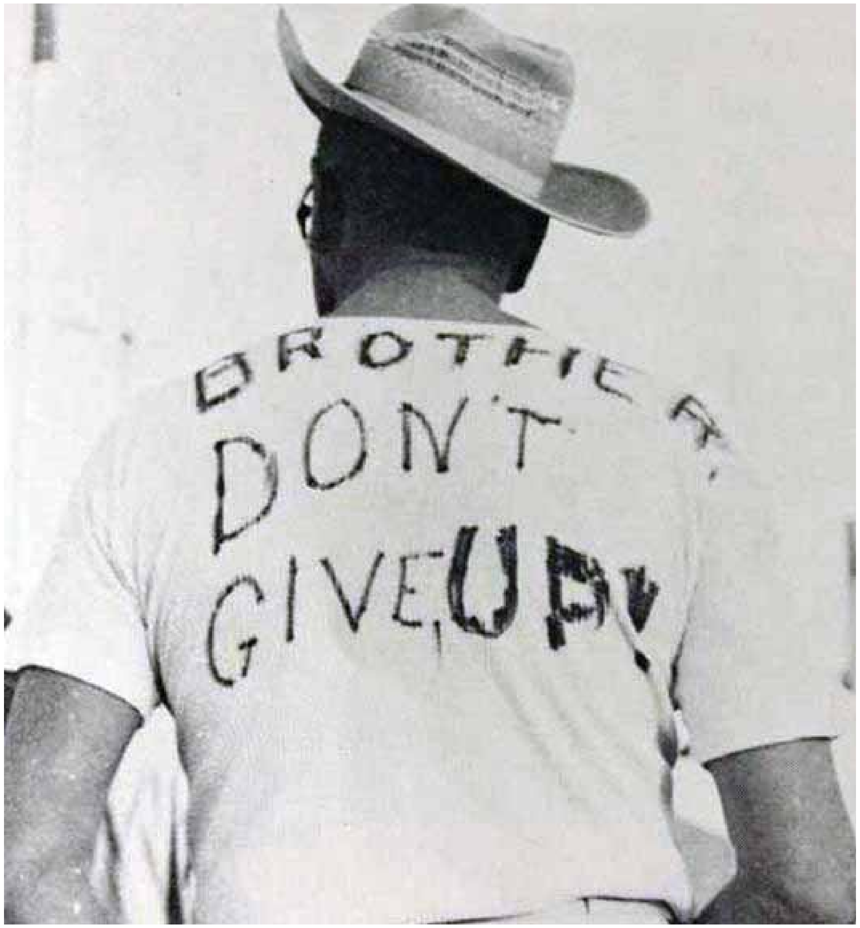


Image from the Mount Isa Mines strike of 1964-65 by the Mount Isa Family History Society

"They could also see there was going to be a very big demand for metals. I used to walk into the mine offices and talk about the problems they had, and what could be done to solve those problems, what it would cost. And by the time we had finished the discussion, the project in that particular plant had been set up."

The year of 1967 saw the first venture into process control. Ken Dredge, an MIM instrument engineer, designed an analogue computer control system for one of the grinding circuits in the No 1 Concentrator.

An equation was derived from the cyclone model to predict product size – now it would be called a soft sensor – and a variable speed drive was installed on the cyclone feed pump to control sump level.

Control of ore feed rate was based on the predicted product size.

Circuit stability improved and throughput increased. This was a major achievement and a vital contribution to the success of P9.

DEVELOPING A REPUTATION

In the mid-1960s, the small JKMRC team was still proving itself. Despite the curtailment of experimental work by an eight-month strike at MIM, the team was able to continue with its modelling work in Brisbane.

Simulation using the University digital computer predicted that a rearrangement of a MIM grinding circuit consisting of a rod mill, three ball mills and six cyclones would increase capacity.

As soon as the new circuit was operated, the prediction was realised. The managers were jubilant.

"That phone call from Mount Isa, telling us about the increase, was the reward for five years of hard work," Lynch recalls.

AUSTRALIAN FIRST

At the end of 1968 an Australian first was conducted – a trial using the PDP8 computer to apply digital control of a test grinding circuit at MIM.

This temporarily replaced the existing analogue computer control system. It was also the one of the first digital computers to be installed anywhere in a plant.

The trial was highly successful.

MIM management moved quickly to acquire a new computer for permanent digital control. Over the next few years, the PDP8 was installed in a number of project sponsor plants where it demonstrated the productivity gains made possible by digital control.

CRUSHER CIRCUITS

The late 1960s also saw a significant achievement in modelling and controlling crusher circuits.

It was Bill Whiten who, after sampling MIM's No 2 Concentrator crusher plant and developing models of crushers and screens, designed a control system that resulted in a considerable increase in crushing plant throughput.

Together, the crushing and grinding circuits operated at capacities up to 20 percent higher than previous.

By the end of the decade, the P9 project had produced spectacularly successful results, with the installation of on-line computer control in mineral processing in some Australian plants.

COMPUTERS AT THE FORE

Increased emphasis on computer control in plants was a notable feature of a further three-year renewal for Project P9 in 1971.

An important addition to the comminution work was the first investigation of autogenous milling.

Inside a PDP8 computer

The former Peko mine in the Northern Territory

Geoff Stanley, an experienced metallurgist from South Africa, joined the centre as a mature age student. He was familiar with autogenous grinding as used in the South African gold industry.

Stanley conducted experimental work on the autogenous mill at Cobar in NSW and at Peko in the Northern Territory where he became famous when he arranged for the entire contents of the mill to be emptied into an area on the mill floor enclosed by sand bags.

Geoff sized the entire contents – a task that took many weeks and included tonnes upon tonnes of material.

The outcome was a unique data set which formed the basis for the JKMRC's first autogenous mill model in 1975. Autogenous grinding was to become a PhD topic for many subsequent students.

THE RIGHT INSTRUMENTS

It had become all too apparent with the comminution and flotation work that more and better-quality data were urgently required to improve models and to make real advances in process control.

The start of a new research direction for the JKMRC in 1971. Using funds from the MIM grant, Lynch employed two postdoctoral researchers – Karl Bartusek, a physicist, and Bill Jolley, a chemist. The aim was for both to explore the development of instrumentation to provide new data for process understanding and modelling.

The instrument development they started in support of industry-based research was to become a theme for many years and to prove remarkably successful.

Jolley went to work exploring flotation pulp and froth characteristics. While flotation chemistry work was not new, examination of froth properties – colour and texture being two examples – was novel.

Decades later, instrumentation and associated control schemes were successfully developed based on froth characteristics, and JKMRC was at the forefront of the developments. Bartusek was given the problem of measuring the size distributions of coarse material on a conveyor.

In the pre-1970s, when fine crushing preceded rod and ball milling, measuring feed size to the mills was not critical. However, as autogenous and semi autogenous grinding were increasingly introduced during the 70s, feed size to the autogenous mills was a critical variable.

Bartusek developed a light source, camera and detector system for inferring coarse particle size. This was the beginning of image analysis work at the centre.

Eugene Gallagher joined as a student from the University Physics Department and teamed up with Bartusek. A system was tested at MIM with encouraging results.

Foxboro, a long-established USA instrumentation and process control company, and major supplier to the world-wide minerals industry, was impressed. The JKMRC sizer was licensed to Foxboro for manufacture and sale, marking the first centre development to enter the commercial market place.

In retrospect, the seeds of JKTech were sown almost 10 years before it became a reality.

OVERCOMING COMPOSITE PARTICLES

Lynch understood the need for a better way of coming to grips with the composite particle problem – where particles are so big that they are made up of a mixture of valuable minerals and useless gangue minerals. Too many composite particles present the danger of losing valuable minerals to waste, or of ending up with excessive valueless gangue in the final concentrated product.

An opportunity presented itself when John Hall, a geologist, joined the JKMRC as a student. During 1973-77, Hall was assigned to study composite particles. What started as a project to identify difficult

Sampling from a semi autogenous (SAG) mill

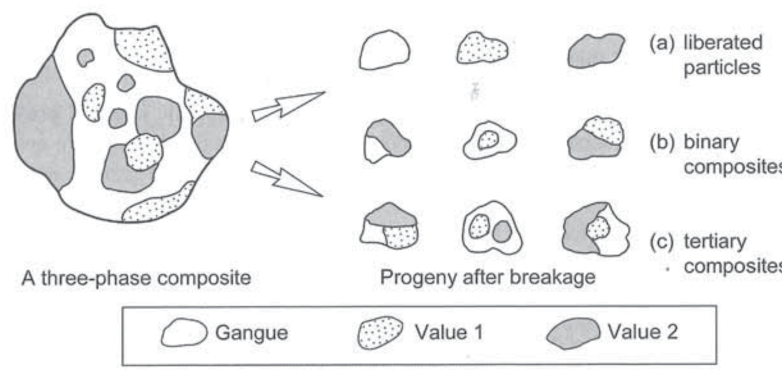
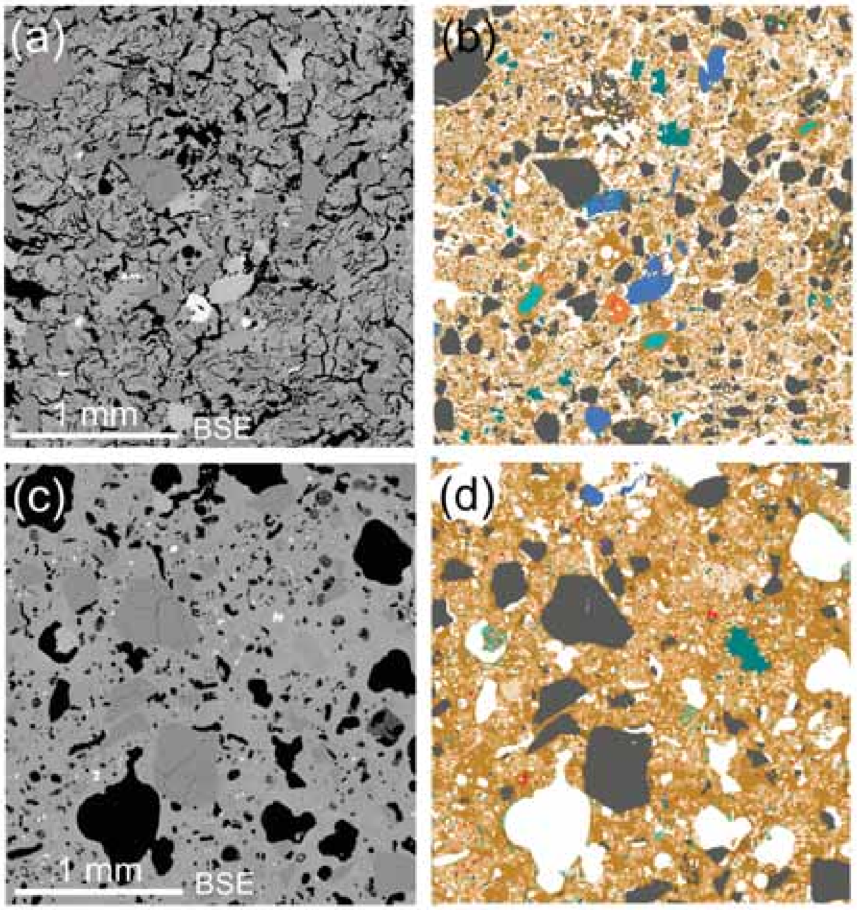


Figure 3.1: Varying mineral associations in the progeny particles from breakage of a multiphase composite

Diagram expaining composite particles



Scanning electron microscopy based automated mineralogy (SEM-AM)

particles in a section of a flotation circuit became a major project concerned with recognising and defining compositeness in particles.

Electron beam microprobe/beam scanning microscopy was chosen over light microscopy because the method offered greater potential for an automated system and because Hall had prior experience with the technique.

Fortune smiled on Hall when he visited the CSIRO Division of Mineral Chemistry in Port Melbourne to explain the measurement idea, with the hope of inspiring the research leader, Alan Reid, to collaborate with the JKMRC.

This was a new research angle for Reid and a means to demonstrate and accelerate the division's capability to serve Australian industry.

After consultations between Alban Lynch and Reid, an informal joint venture collaboration was set up where the JKMRC supplied the student to define and assist the development of the scanning electron beam to characterise compositeness of particles.

The rapid establishment of the informal relationship would be less likely today.

Much work was required from the collaborating team during 1974-76 to ensure the computer-microprobe interface functioned reliably. The crucial factors in eventual success were the enthusiasm and technical drive supplied by Hall, and Reid's ability to assemble a number of outstanding CSIRO talents spanning programming, electronics, statistics and microscopy.

By 1977, the JKMRC thesis project had a working name, MINSCAN, and had reached its proof-of-concept goal, with over 100 flotation concentrate samples from Silver Bell, Rosebery, Bougainville and Tennant Creek being measured with this prototype. Subsequently, Bob Allen and Nigel Cleminson completed PhDs using data provided by MINSCAN.

Hall joined the CSIRO team after completing his PhD and worked on the development of the first commercial version of the system, known as QEM*SEM. Thus emerged the second commercial product which had its origins in JKMRC research. QEMSCAN – the descendant of this system, and a close relative of the MLA, is still in common use today.

BLASTING AHEAD

The second area of diversification for the JKMRC was into the field of rock blasting – the first stage of comminution in the minds of the JKMRC.

The original idea belonged to Gordon Toll, a mining graduate from the department who, in the mid-70s, was a senior engineer at the Mount Newman iron ore mine. PhD student Mark White had been doing crushing and screening work at the location.

Toll understood that current blasting practice was inefficient and that little was really known about the basics of blasting. He wondered if the JKMRC approach to understand crushing and screening could be applied to blasting, and he approached Lynch with the idea.

The JKMRC ran a feasibility study in 1977, funded through AMIRA, to investigate the opportunities for a project to investigate rock fragmentation by blasting. The work was undertaken by Graham Walter, whose initial training was in physical metallurgy.

Walter had a rare ability to come to grips with other technical areas, as was earlier demonstrated when he led a project concerned with crushing and screening operations at Bougainville Copper.

The feasibility study revealed significant inefficiencies in the blasting process. It also revealed that mining engineers on site had limited understanding of the blasting process. Blasting was hardly a science in those days.

The feasibility study quickly resulted in a new AMIRA funded project in 1978 – Optimisation of Explosive Rock Breakage. It became P93 in the AMIRA system and, informally, the AMIRA blasting project.

The project lasted until 1994.

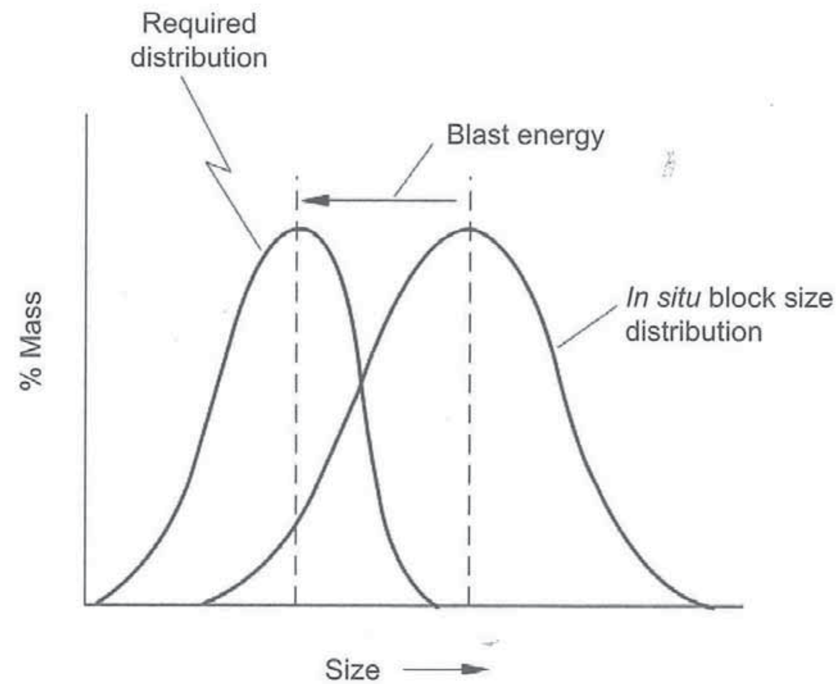
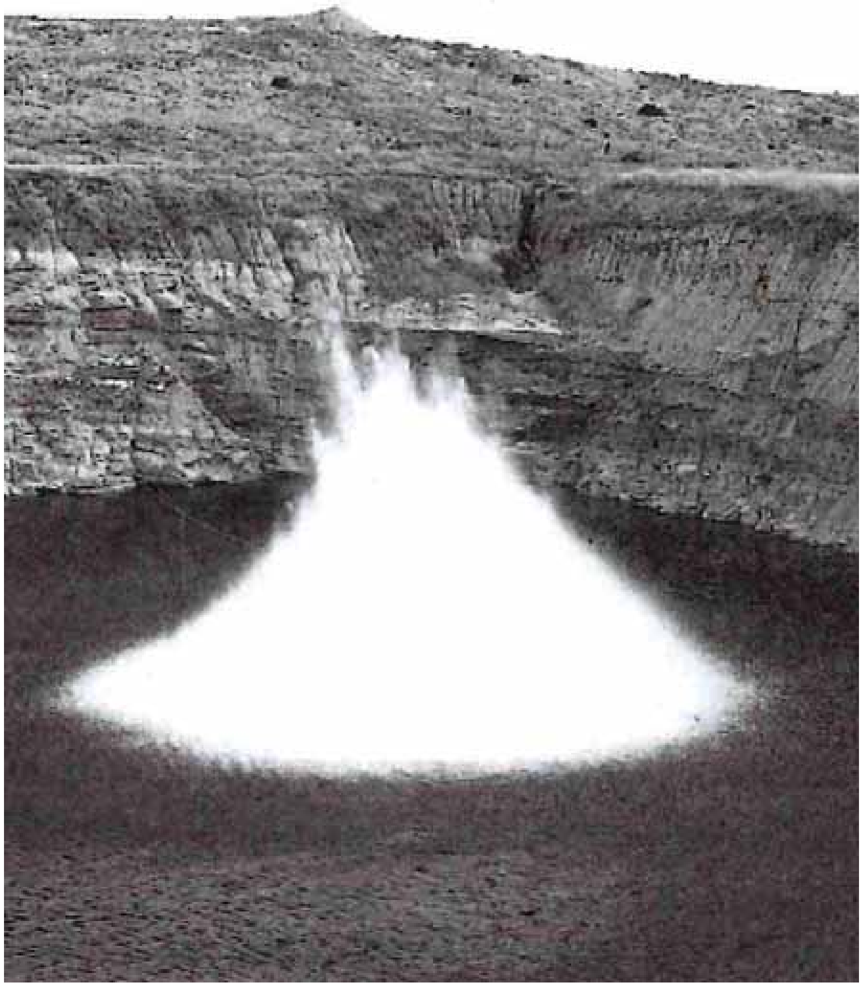


Diagram of the fragmentation process from blasting



Eruption from underwater blasting test

Lynch was not deterred by the fact that the JKMRC had no experience in the field, nor even that it had no mining engineers on the staff. Cameron McKenzie, the metallurgist who had been working on coal flotation, was asked by Lynch to lead P93 and he agreed.

This was an inspired appointment. McKenzie set to work to acquire an understanding of the current state of the art in blasting and to form a project team. He was to become a great leader of the research, possessed of energy, drive and the ability to inspire the team.

McKenzie was not put off by the daunting experimental challenges to be identified and overcome. If mineral processing experimentation in plants had challenges, those faced in blasting in mining operations were many times more daunting.

McKenzie began by following the usual methodology of site-based experimentation to be followed by modelling and simulation.

From the outset it was clear that the instrumentation simply did not exist off-the-shelf to monitor blasting in real time. The equipment had to be developed by the project. So began the most challenging instrument development work undertaken by the JKMRC. It was also the most important since, without adequate instrumentation, the project would fail.

Initially the project turned to Geoff Just, a reader in mining engineering in UQ's Mining Department and Mick Gladwin, a staff member in UQ's Physics Department and an expert in geophysics. Jim Shields, a technician in the Physics Department, joined the project.

Over the next few years the group assembled systems to monitor the detonation of explosives and results of blasting. Seismic monitoring methods were at the core of the experimentation. The blasting project really hit its straps in the early 1980s and some of the activities are captured in the next chapter.

PILOT GROWS WINGS

The Indooroopilly pilot plant had always been the place where laboratory work was conducted to support the on-site plant studies. There was little there in the way of fancy equipment to impress visitors.

But that started to change during the 70s.

Egon Ostergaard joined Jack Norris in designing and constructing new experimental facilities, the most striking being the large cyclone test rig constructed for TC Rao.

In the years to come the pilot plant was transformed into a major research facility.

By the end of the 70s the JKMRC had become an established entity. Its industry associations, research methodology and student workforce were one aspect of its culture.

SPECTACULAR LEAPS

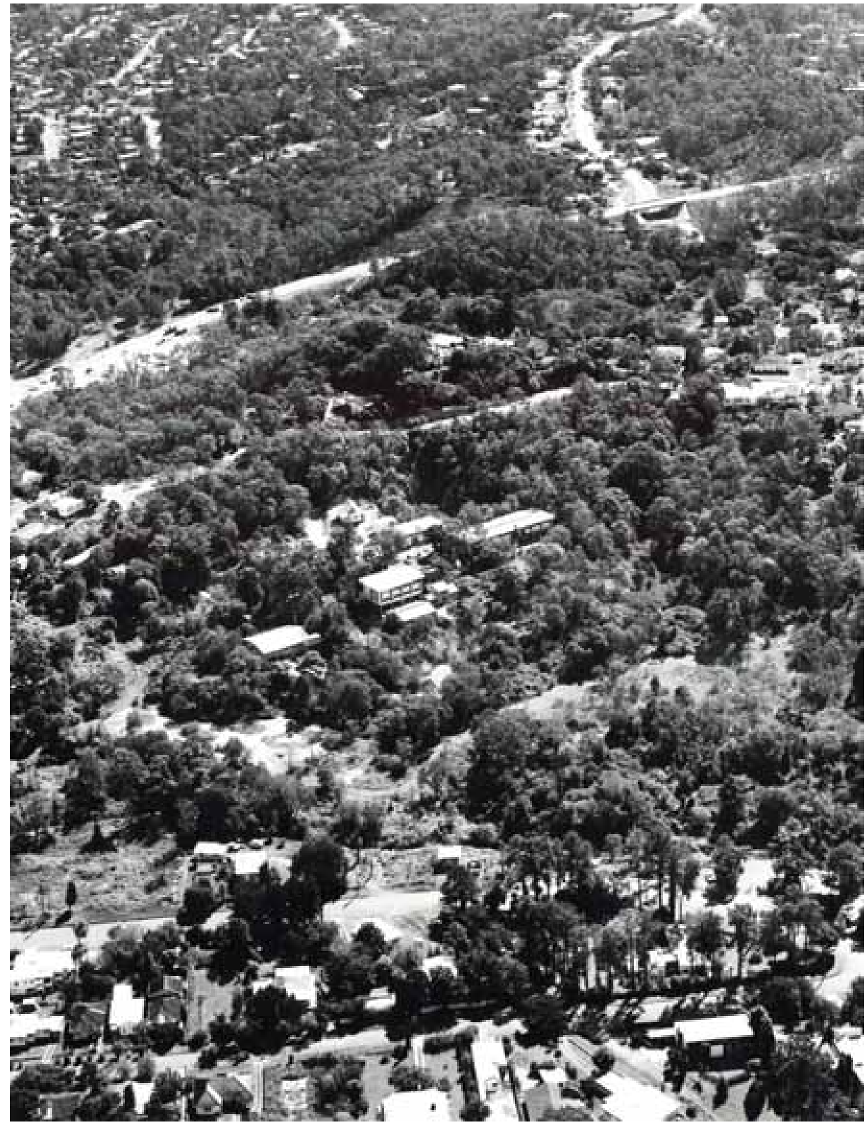
If the seventies were a springboard, a careful dive into areas that built on the foundation years, the eighties showcased some spectacular forward leaps for the JKMRC and all its personnel.

The 1980s began with the JKMRC diversifying its research activities, weathering financial problems through its own efforts, and expanding the industry support base, both nationally and internationally.

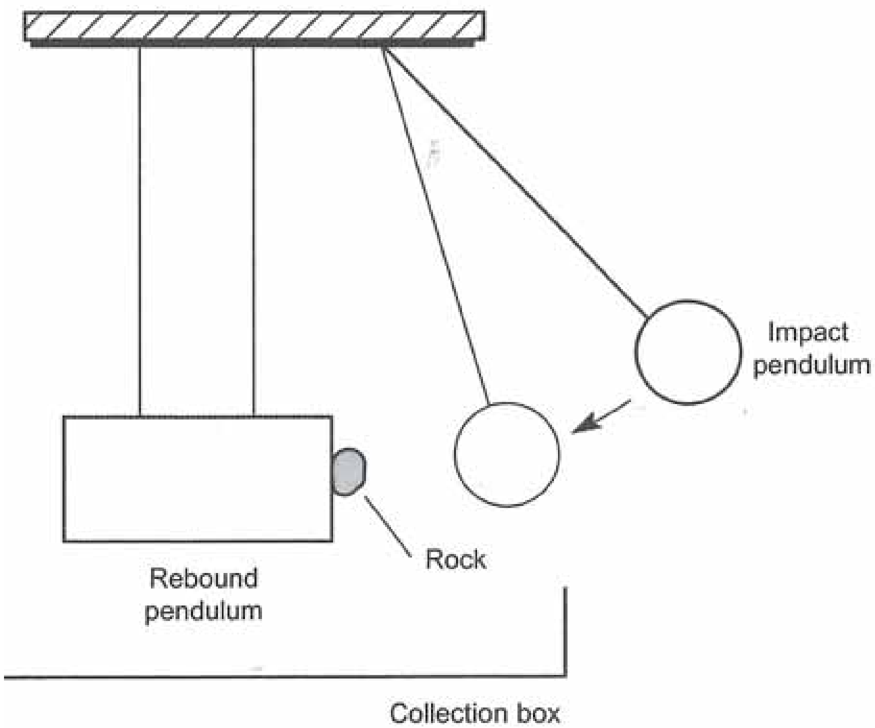
In terms of research achievements, the important developments of the decade were the proving of process control in many plants, the first autogenous mill models, the new research into coal flotation and rock blasting and the beginning of work on measurement techniques.

The centre was ready for dramatic growth and some remarkable new achievements.

Rapid growth — in staff, graduate students and in the range and diversity of projects — made this a decade of significant change.



Aerial shot of the JKMRC and surrounding area in 1979



Schematic from a twin pendulum device

By the end of the 80s the centre would be a different place from the one that began almost 30 years before – it had become an institution, famed worldwide for its innovation, its unique methods and the quality of its outcomes.

THE PENDULUM SWINGS

Project P9 was renewed for the sixth time in 1980. This brought a new group of students, mainly working on traditional modelling, simulation and control studies.

Flotation circuit analysis and control studies were undertaken by new students—Tom Kleine, Andrew Thornton at Cleveland Tin and Bougainville, Carol Smith at Zinc Corporation and MIM and Mike Casey at Renison.

Fred Hess further developed screening models and Bill Hutton produced a model of a drum scrubber, as used at Groote Eylandt.

In essence, these studies demonstrated the benefits of process control in sponsor plants and extended the modelling capability of the JKMRC.

It was the old firm, Alban Lynch and Bill Whiten, who were responsible for the two ideas which breathed new life into P9. In 1981 Whiten began thinking about a testing procedure to develop an ore specific breakage function for the comminution models. The first experiment was simplicity itself.

An undergraduate student dropped rocks from a known height onto a concrete floor, and then measured the resulting size distributions. The energy available for breakage was known from the mass of the rocks and the drop height.

The next step was the design of a twin pendulum system for breaking single particles at a range of input energies. This became the PhD of SS Narayanan, always known as Narayanan, another student from India like TC Rao whose work had a major influence on JKMRC research.

Whiten conceived three breakage and size distribution parameters, curiously named A, b and t10, which were to become standards in comminution modelling around the world.

In 1990, a twin pendulum breakage device, based on Whiten's original design, was sold to Chino Mine in the USA, marking the commercial evolution of a brilliant concept.

Many moons later, Toni Kojovic and Frank Shi developed the rotary breakage tester, the latest in a long line of breakage testers over a period of more than two decades.

THE RIGHT COMPUTATIONS

Another major development for the JKMRC was directed at simulation.

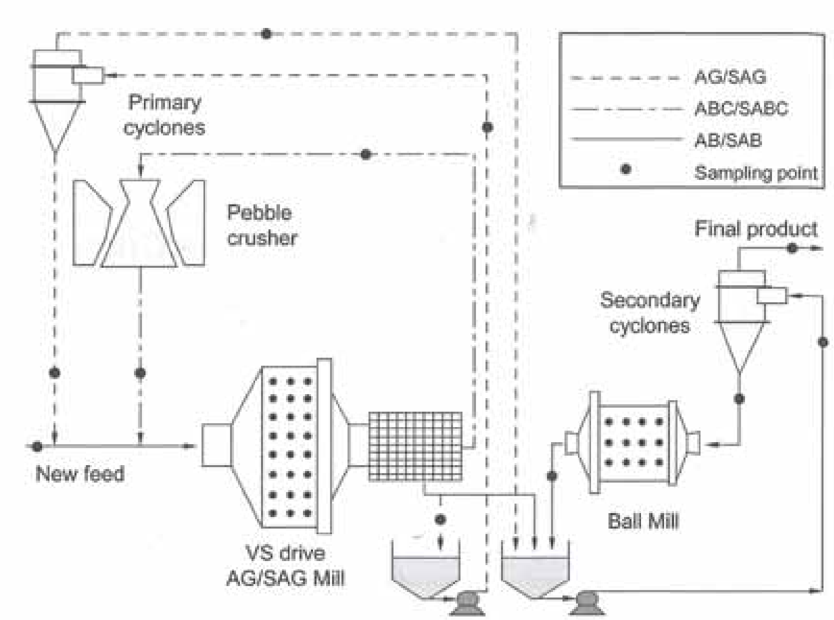
By this time the centre had a well-tested set of comminution and classification models and Whiten's FORTRAN subroutines, known internally as GSIM, for circuit simulation. JKMRC staff and students became proficient in their use.

Many AMIRA sponsors acquired this simulation capability but, with few exceptions, found it too difficult to use the software effectively. Increasingly, sponsors would send staff to the centre with a specific simulation problem. The work would be done under the guidance of the JKMRC.

In practice, this was not a very effective use of the methodology. What was needed was not just training for engineers and others, but a specially designed user-friendly version of the software.

Tom Kleine was responsible for the first version – a fixed ball mill-cyclone circuit displayed on a colour terminal. A limited number of circuit variables could be changed, with simulation showing the results on the screen.

This simple prototype was well received at an industry course in Adelaide. Subsequently, Lynch raised the matter of the simulation software with AMIRA chief Jim May during a long conversation on an aircraft. Before they'd landed a decision had been reached.



Typical schematic diagram of a comminution circuit

Modern COALSCAN machine, derived from foundational work by UQ RESEARCHERS

One aspect of the next extension of the hardy P9 project, due to begin in 1983, would involve the development of a simulation system for non-specialist use. It was the arrival of the personal computer which was the key to this development.

PRECURSOR TO COALSCAN

While the coal preparation group at the centre was always small, it achieved remarkable success during the 80s.

The decade began with Lyman working steadily towards the development of an on-line ash analyser for coarse coal. His partner in the work was Dr Brian Sowerby from CSIRO.

Lyman designed, and Egon Ostergaard built, a test rig at the pilot plant to test his concepts. Lyman developed and patented a 300mm vertically placed shaking tube which received a sample of coal particles.

Sowerby designed the radiation source and detector systems which provided data for calculation of the ash content of the coal. This became the second significant instrument development undertaken by the JKMRC.

The resulting ASHSCAN system was subsequently licensed to an Adelaide company, Mineral Control Instrumentation, which designed and manufactured an industrial version that was sold as COALSCAN worldwide.

TRIAL BY SEPARATION

The modelling of dense medium separation in metalliferous operations was a new element of the 1983 P9.

Dense medium cyclones were used in iron ore beneficiation plants and for tin at Renison, and MIM was in the process of building a pre-concentration plant for its lead/zinc ore using dense medium techniques, which in metalliferous mines are designed to separate the denser valuable minerals from the less dense gangue minerals at the earliest possible stage in the processing stream

The NERDDC coal preparation project had begun work on dense medium cyclones in coal preparation plants some years before.

Lyman, the leader of the coal preparation group, took on the task of initiating the metalliferous studies. The first student was Iain Scott. One of his achievements was the development and casting of metal blocks of a range of specific gravities for use as tracers in plant trials.

Scott turned to Len Hogan, Reader in Physical Metallurgy in the department, who assisted by selecting appropriate alloys for the tracers.

TRACERS IN ACTION

The focus of coal preparation research turned to the modelling of dense medium cyclones, undertaken by Chris Wood and Jon Davis, with the work funded by AMIRA and NERDDC.

This was the first coal preparation work undertaken by AMIRA. A direct spin-off of the dense medium work was the development of low specific gravity density tracers.

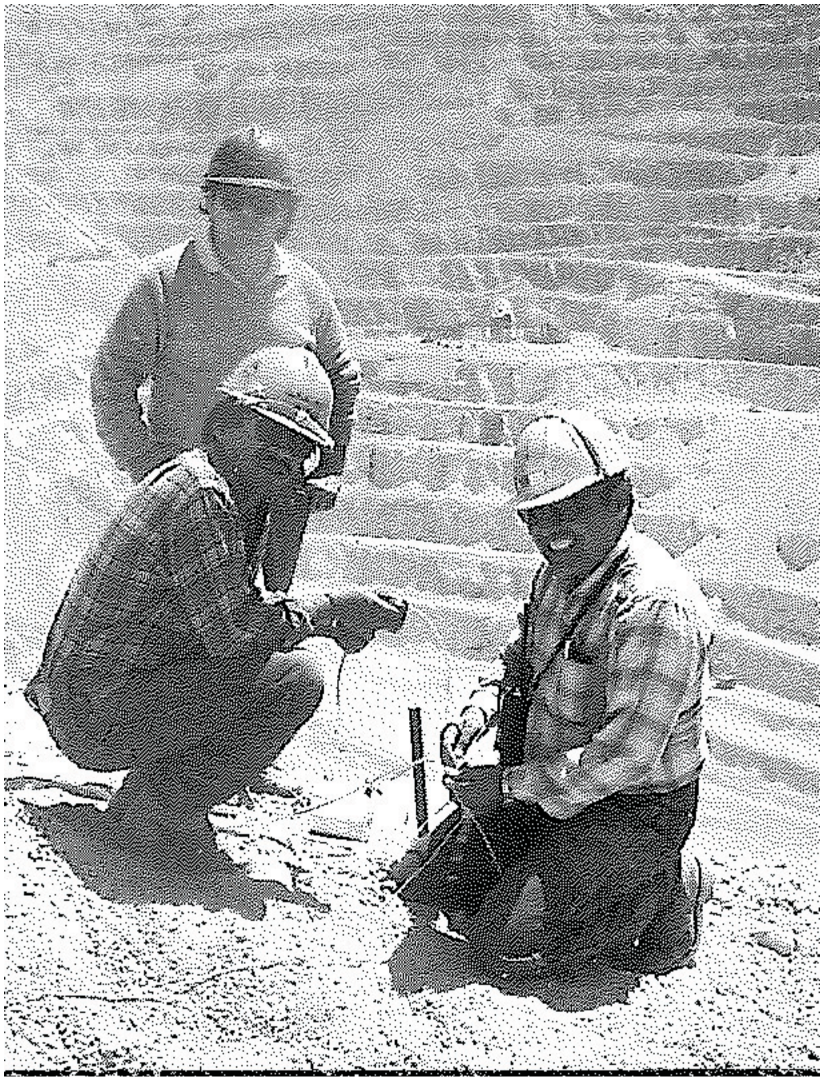
Subsequently Lyman, Wood and Davis formed a small company, Partition Enterprises, to manufacture and market the tracers, a company which continues today under Wood's leadership.

The newly opened Newlands coal mine in the Bowen Basin, more than 100km directly west of Mackay, provided the next opportunity for the coal group. Newlands installed Batac jigs, and Lyman and David Hughes, the preparation plant superintendent, formed a powerful partnership.

It was focused on understanding the operation of the jigs, with the aim of developing a control system. A small jig was built in the pilot plant to support the site studies, and the rig provided the basis for Richard Rong's PhD.

Chris Wood still operates the business Partition Enterprises

Density tracers


Preparing for high-speed blast photography in Chile

Lyman and Andrew Jonkers successfully installed a jig control system at Newlands, another first for the JKMRC.

Lyman also turned his hand to the modelling of coal washability, having taught himself the basics of geostatistics.

This work was supported through another AMIRA coal project and formed the basis of Dean Ilievski's Master's degree. Looking back, the breadth of original work undertaken by Geoff Lyman during the 80s was quite remarkable.

FREEZE FRAME

High speed photography was used to record open pit blasting in real time, as P93 progressed steadily during the early 1980s.

Funding renewals were made in 1981 and 1984, with blast monitoring techniques developed and perfected, and equal effort devoted to measuring the outcomes of blasts.

Factors analysed included the shape of muckpiles (the post blast rock mass), sizing distributions of blasted material, and damage to rock adjoining blasted areas. This work was novel and world leading.

Slowly, some of the mysteries of blasting became apparent, particularly problems associated with actual detonation sequences which did not perform as designed.

THE COMING OF BART

Project P93 provided the springboard for a new AMIRA Project, Blasting and Reinforcement Technology (BART), which commenced in 1995.

BART focused on characterisation of the rock mass in terms of blasting and geotechnical requirements. It was led by Gideon Chitombo and provided the ideal vehicle for him to pursue his strong interest in blast damage.

BART led seamlessly towards Chitombo's interest in cave mining methods.

Finally, the project was the ideal vehicle for Brown to direct the geomechanics aspects through supervision of a new group of students, including Neal Harries, Tao Li and Ian Brunton.

A visit by Ken Owen, a senior DeBeers mining engineer, to Chile in the early 1990s resulted in a significant mining development for the JKMRC.

Owen learned about JKMRC blasting work conducted at the El Teniente underground mine as part of P93D. Owen contacted the JKMRC and, as a result, Scott visited the South African underground diamond mines in South Africa. This led to a quarter-century association between DeBeers and the JKMRC.

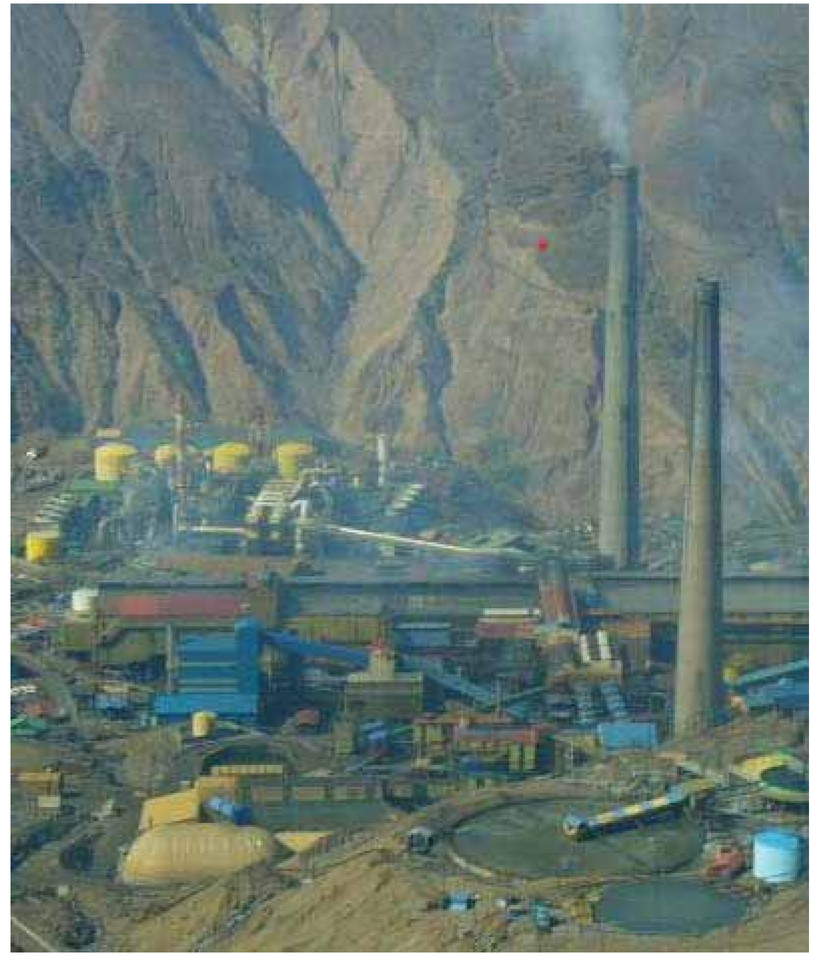
NEW COAL ACTIVITY

The diversification of mining research began in earnest in 1992 with new coal-related activity.

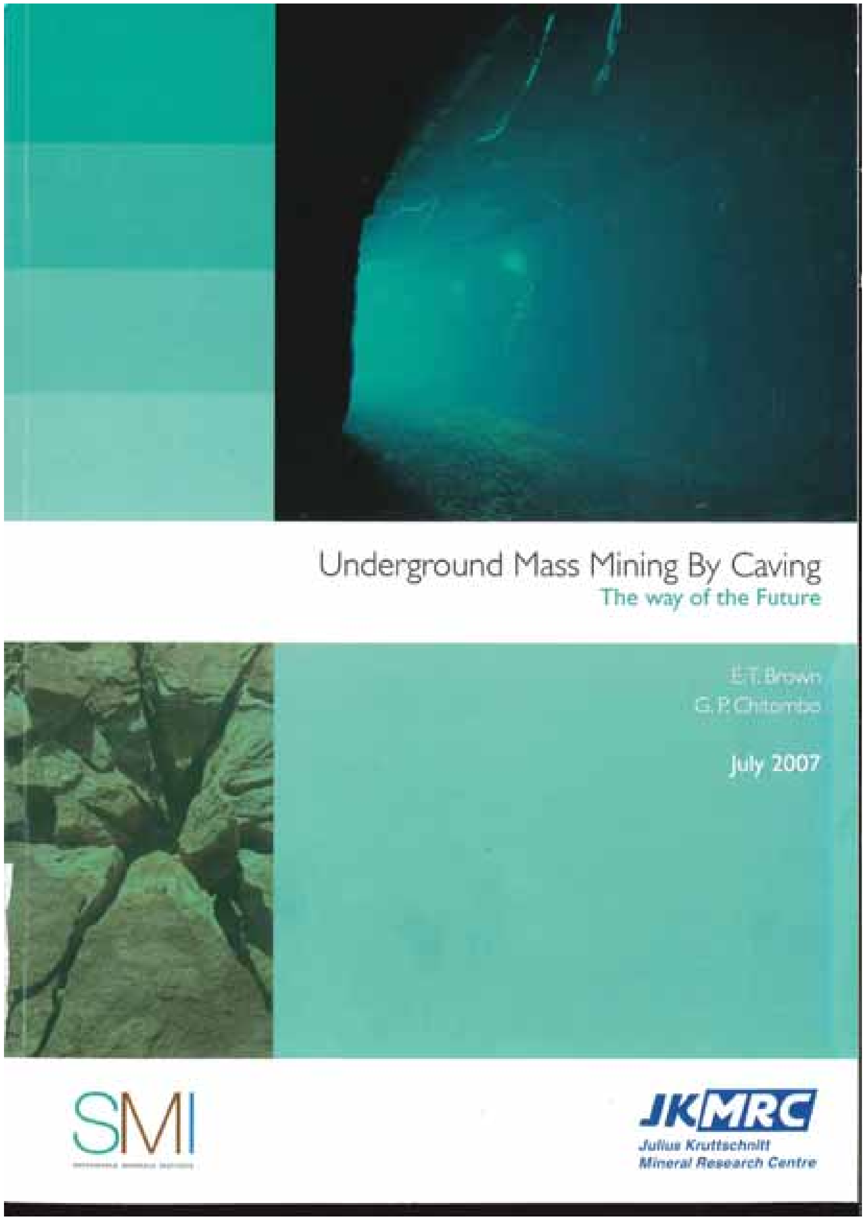
ACARP funded a project to investigate the mechanisms of coal loss in open cut mining and Pacific Coal funded a project to improve dragline productivity through simulation.

The coal loss project was the first of many studies on this topic. A related study by Scott and Chris Wood at BHP's Saraji mine, tracked coal loss from in situ through all mining, transport stages and coal preparation. It was the forerunner of JKMRC work in mine-to-mill topics.

Some ideas take a long time to germinate. This type of work had initially been envisaged in the original proposal to MIM in 1969 which established the JKMRC.



El Teniente mine in Chile, Credit - Nicolas Schubert



Cover to the book Underground Mass Mining by Caving by Ted Brown and Gideon Chitombo

EXPLOSIVE VELOCITY

Instrument development continued as a major part of the mining research under David La Rosa.

The JKMRC Event Timer, a device to measure the velocity of detonation of explosives, became commercially available through JKTech in 1994.

This was followed a year later by MultiVib, a device to measure vibration data associated with production blasts.

The year 1995 saw the beginning of research planning associated with cave mining. Gideon Chitombo had been introduced to caving operations at the El Teniente mine in Chile and the DeBeers diamonds mines in South Africa. This gelled neatly with his interest in underground blast damage.

There had been little research associated with caving operations in recent years. Together with Alan Guest of DeBeers, Chitombo developed the first caving project which began two years later.

Known as the international caving study (ICS), the topic continues today. ICS was to all intents an AMIRA-style project, but it did not involve AMIRA and was managed through the JKMRC.

Apart from NERDDC and ACARP projects, ICS was the first substantial industry funded project – it had nine company sponsors – without AMIRA involvement

Professor Brown acted as consultant to the project, along with South African expert Dr Dennis Laubscher.

Chitombo was joint technical project leader with John Markam from Itasca, a specialist consulting group based in Minnesota. The project aims included the production of a handbook for practitioners on caving methods, a database of state-of-the-art caving methods and practices and a web page for the data base.

FLOTATION RESURFACES

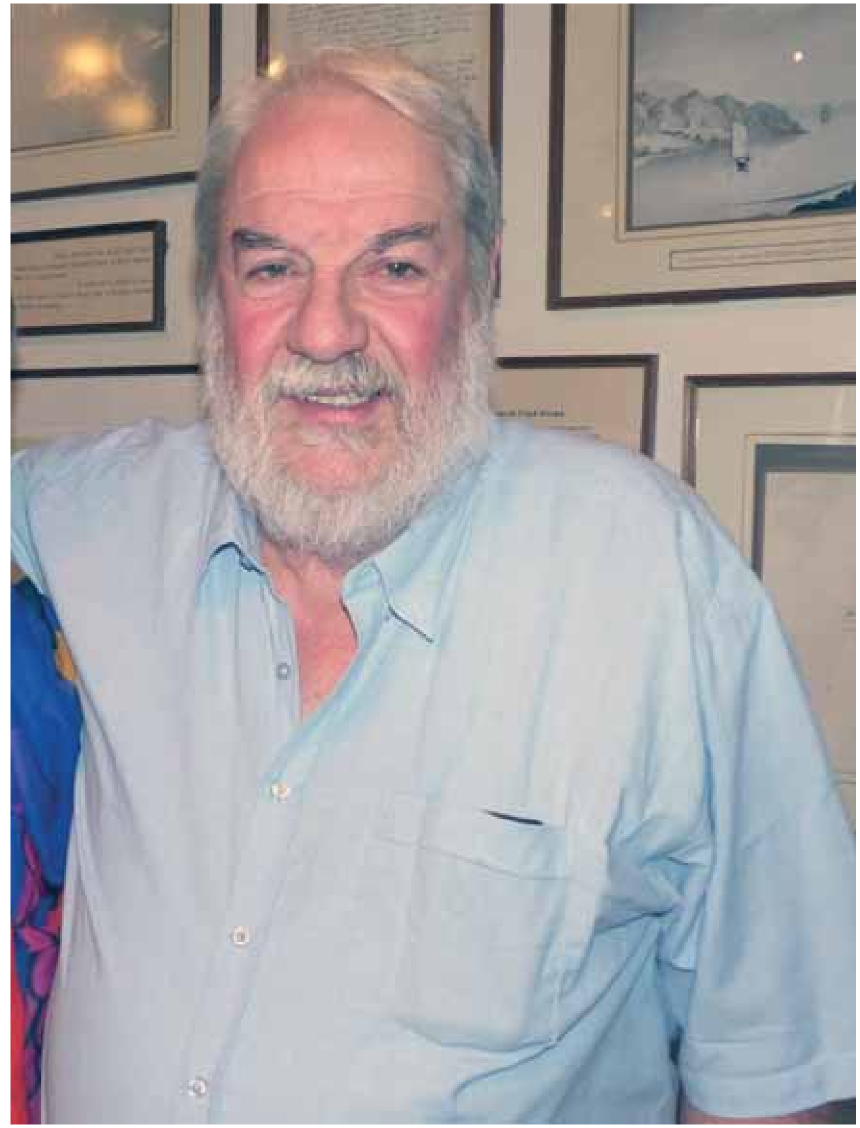
Flotation modelling, which had been such a feature of P9 work from the late 60s onwards, had momentarily lapsed after the studies of the 80s.

However, Emmy Manlapig and Tim Napier-Munn proposed a bold plan in 1992 to re-establish flotation research at the JKMRC under the banner of P9.

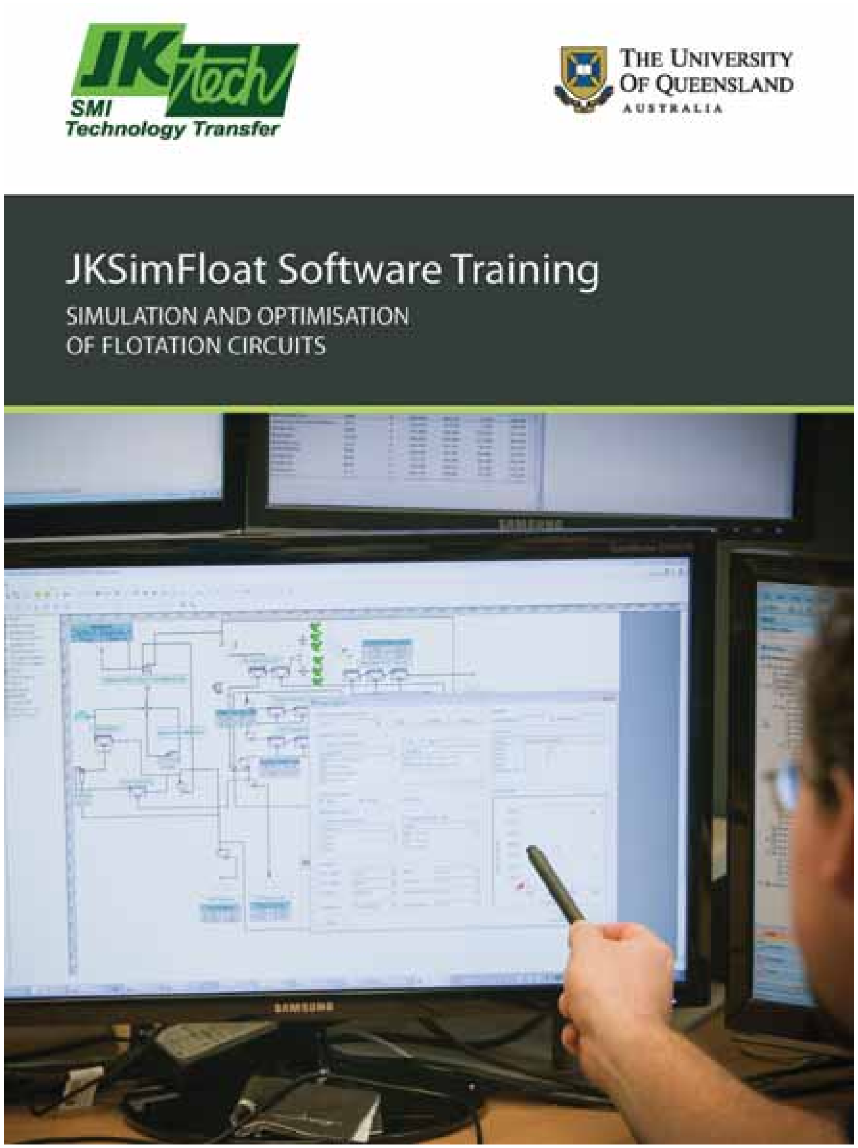
Manlapig and his team of students were to transform flotation modelling. A large flotation cell was constructed at the pilot plant, allowing the measurements of its hydrodynamic properties. A link with UCT provided access to their bubble size analyser which yielded critical data. Barun Gorain ran the cell at mining operations around the country using the bubble sizer and in a seminal piece of work, showed that the rate of flotation was proportional to the rate of bubble surface area rising within the unit. This outcome paved the way for the later development of a flotation model where flotation cell operation could be decoupled from the effects of ore properties. Fortune smiled when Jean Paul (J-P) Franzidis from South Africa spent a sabbatical year at the centre in 1994. He formed a powerful team with Manlapig and, most importantly, had the time to mentor and guide the flotation students with the analysis of their data. New modelling concepts rapidly emerged.

The link was complete when Franzidis joined the JKMRC permanently in 1996. Franzidis facilitated connections with the University of Cape Town who became an important collaborative partner within the P9 program. Key UCT flotation researchers, such as Martin Harris, Dave Deglon and Jenni Sweet became regular visitors to the JKMRC. The floatability component modelling approach that Martin developed in his research dovetailed with the findings of Gorain and would ultimately form the basis of the JKSimFloat program.

Many important insights, models and flotation diagnostic techniques emerged during this period of collaboration. Flotation group meetings at the JK were a hub of creative endeavour. Students such as Orivaldo Savassi, Marco Vera, Sergio Vianna, Kym Runge and Barun Gorain



J-P Franzidis was the perfect fit at the perfect time for the JKMRC



JK SimFloat flyer

would sit around a table each week and engage in a heated debate of ideas. They were joined in the following years by Xiaofeng Zheng, Dan Alexander, Ken Rahal, Rob Coleman, David Seaman and Brigitte Comley and Rena Varadi and Simon Welsby. Many of these students have gone on to be the technical thought leaders in mining companies around the world.

Flotation in P9 would later grow to include researchers from the University of Newcastle, McGill University in Canada, the Federal University of Rio de Janeiro and Hacettepe University in Turkey. A large ARC Linkage grant was successfully leveraged from the industry P9 sponsorship to help fund what had grown to be a large and successful research collaborative.

EMERGENCE OF A NEW SIMULATOR

The first version of JKSimFloat, for flotation circuit simulation, emerged in 1993. Bob Alford in conjunction with Michal Andrusiewicz, modified existing code to enable simulation of minerals within a flotation circuit. It was essentially an in-house product and remained on the shelf until it was uncovered by Kym Runge almost a decade later. She recognised that it could be modified to incorporate the newly developed flotation models emerging from the P9 collaborative flotation program. Working in combination with Michal, she created a demonstration program which was showcased during a P9 meeting held in Strahan in Tasmania, where industry leaders were pitted against each other to use the program to optimise their flotation circuits.

On the back of this demonstration, sufficient interest was garnered to motivate a new AMIRA project to fund the development of a Windows based JKSimFloat program. The Queensland government was lobbied to provide additional funding. This program would incorporate not only simulation capability but a mineral by size mass balancing algorithm developed by Stephen Gay. A team comprising UQ and UCT researchers, as well as JKTech consultants, was assembled to design, code and test the program. Bob Lasker was the lead programmer, with Michal and others providing support. Bill Whiten came to the fore once again, providing a unique mineral stream structure that was flexible and configurable. Kym Runge designed the interface and programmed the P9 models into the simulator. Stephen Gay was responsible for the mass balancing algorithm. Sarah Schwarz and Jenni Sweet were among the testers who got rid of the bugs. The project was led by J.P. Franzidis, with Martin Harris and Ricardo Pascale also part of the team.

This new version of JKSimFloat was released in stages post 2003 and to this day remains part of the suite of simulators sold by JKTech, albeit with a smaller user base than JKSimMet.

MORRELL TAKES DIRECTION

In 1990 Tim Napier-Munn passed leadership of P9 to Steve Morrell.

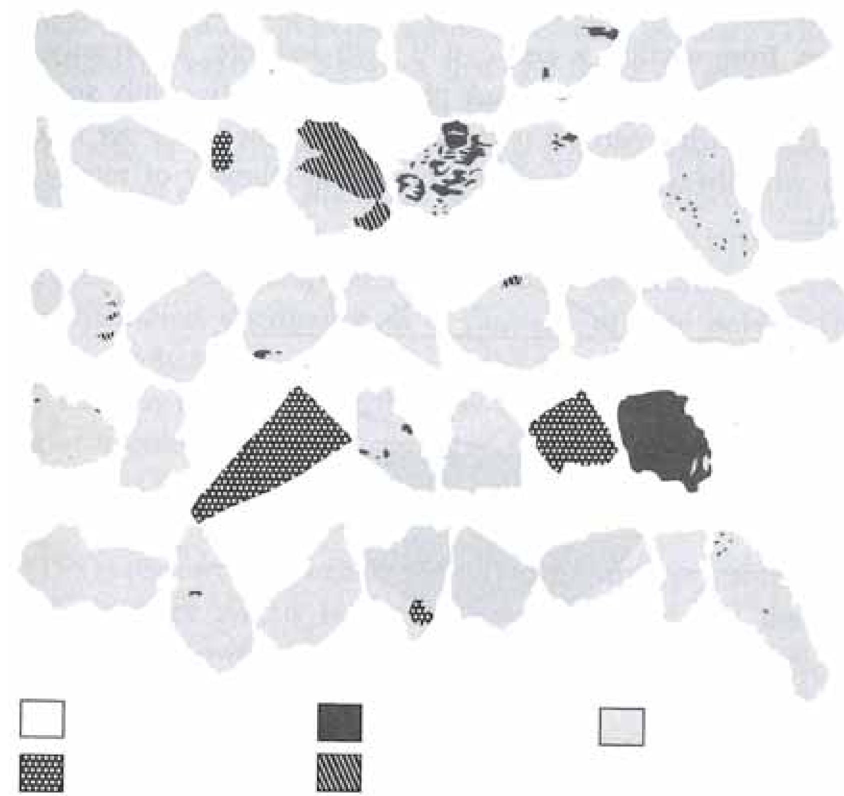
Morrell ran the world's largest University-based mineral processing research project while completing his PhD on power prediction in tumbling mills in only three years.

Subsequently, he passed leadership of P9 to Franzidis in 1996.

In addition to Manlapig's flotation research there were significant advances in autogenous grinding models, notably the mill power prediction methods of Morrell and the dynamic modelling work of Walter Valery.

Work investigating slurry rheology effects in grinding was undertaken by Frank Shi. The particle breakage studies pioneered by Whiten in the 1980s were expanded via a new drop weight testing device developed by Doug Brown and Bob Marshall in the JKMRC's pilot plant and workshop.

P9 led the way with two non-technical innovations. Since inception each project extension had been for three years. JKMRC convinced AMIRA and the sponsors that four-year extensions were more efficient, with the first longer project beginning in 1992.



Example of a QEM SEM false colour map, showing liberated and composite particles

This change probably increased the productivity of P9 by about 30% as time was not spent re-selling the project every third year.

In the late 90s, P9 became the first ever AMIRA project to have a contract. It took years to finalise and was not signed till the next project cycle had begun. An important clause gave JKTech first right of refusal over any third-party commercialisation arising from the project.

SANDS OF TIME

Titanium, sourced from beach sands rich in heavy minerals, is the main source of whitening agents for paints, foods, and even toothpaste.

The 1990s saw the global titanium minerals industry grapple with a host of technical challenges, and sought a research partner to help better understand and improve the electrostatic and magnetic separation processes used in the industry. The JKMRC pursued a major research initiative in the space, successfully sourcing project funding through both AMIRA and other channels.

The next decade saw a new JKMRC team at the forefront of global mineral sands research, as electrostatic and magnetic separation was added to the list of JKMC's research strengths. The program ran until the mid-2000s, with multiple industry-focussed projects completed and products developed, including online measurement devices as well as a short-lived but powerful JKSimSand simulator.

BACK TO THE GRIND

A link existed between the flotation studies within the Fine Grinding Project and Manlapig's new work.

The Fine Grinding Project used the CSIRO QEM*SEM system for mineralogical studies. Despite the JKMRC having initiated what became QEM*SEM, the centre had made little use of the technology.

As the fine grinding and flotation work developed it became clear that increased access to QEM*SEM was essential.

Former JKTech manager Rob Morrison, who accumulated more than 30 years of experience in mineral processing and remains an Honorary Professor at UQ to this day, had undertaken a study investigating the feasibility of the JKMRC embarking on its own microscope development and on the potential for marketing systems and mineralogical services, all with encouraging results.

Before any decisions were taken, JKMRC approached CSIRO to acquire a QEM*SEM system on a payment scheme, which involved offering QEM*SEM services via JKTech.

The approach was not successful, and the stage was set for JKMRC to embark on its most audacious and risky venture of the 1990s—it would develop a system from scratch.

RAPID ADVANCES BEGIN 90s

In 1991, a new drop weight tester replaced the twin pendulum and the first blast design package, 3*3o-PRO, was installed.

A new version of JKSimMet was released, as was a commercial version of the Event Timer, which had been an outcome of P93. JKSimSand and JKSimDM, linked to the Mineral Sands Project and the dense medium research of P9, were released in the same year.

In 1997, JKSimBlast, a completely new version of the initial blast design package, was released. This development had been undertaken by Kai Riihioja, on secondment to JKTech from the mining group.

JKMetAccount was released in the same year. JKFrothCam, for measurement of flotation froth characteristics, had initially been developed by Khoi Nguyen as a PhD student. He subsequently spent a period within JKTech developing the commercial version. The year 1999 saw the launch of a mineralogy bureau service based on the Mineral Liberation Analyser (MLA).

The MLA, a high-throughput, highly-automated technology capable of analysing many different geological samples overnight without

The strength of JKMRC developments continued to be their practicality at the mine site, as well as at the research desk

Preparation of Level 2 of the new Mineral Characterisation Research Facility

The finished Mineral Characterisation Research Facility

the need for a human operator, would become a champion product for JKTech.

Automated stage control and image acquisition allowed thousands of individual particles to be x-rayed for concentrated samples, and tens-of-thousands analysed for low-grade materials.

AWARD-WINNING RESEARCH

One measure of success was the number of awards the JKMRC received in the early 2000s, partly as a consequence of the late David Goeldner's tireless efforts to gain recognition for the remarkable research taking place.

In 2000 the P9 project received the Business Higher Education Round Table Award for international collaboration in research and development. That year the development of JKFrothCam by Peter Holtham and PhD student Khoi Nguyen was acknowledged with an ACARP award.

The mine-to-mill project staff justly received the AusIMM Operating Techniques Award in 2001. In the same year, the JKMRC won the prestigious Automation, Control and Instrumentation National Project Excellence Award.

Presented by the Australian Institution of Engineers, the latter award recognised the centre for its process control work in the titanium minerals industry for the design and development of a conductor non-conductor (CNC) gauge to monitor the electrical properties of rutile and Zircon by Tom Rivett, under the direction of Randolph Pax.

In 2002 an ACARP award went to Geoff Lyman for the development of the JKUltraSort Pycnometer, a device to automatically measure coal particle density. In the same year, PhD student Clare Mawdesley won the Douglas Hay Medal, presented by the Institution of Mining and Metallurgy, for a geomechanics paper. Her supervisors were Whiten and Trueman.

A NEW $6.1M FACILITY

Space had again become scarce at the JKMRC by 2006, leading Ben Adair and Leith Hayes to embark on the challenging task of preparing a proposal for support from the State Government Innovation Building Fund.

Hayes had previous experience in preparation of such proposals and she undertook the task with enthusiasm and determination.

In late 2006 the JKMRC was awarded $6.1m for the construction of a Mineral Characterisation Research Facility, better known as Stage 4 of the JKMRC. The funds were a loan from the Queensland Government and The University of Queensland was require to pay back a portion of those funds, which it duly did.

This building, which incorporated part of the initial Stage 1 from 1971, provided new laboratories, particularly associated with flotation chemistry. The building was completed in 2009 and named in honour of Alban Lynch.

A crowd gathered for the opening of JKMRC Stage 4

CENTRE FOR SUSTAINABLE COMMINUTION

There was a welcome development in 2012 when the Anglo American Centre for Sustainable Comminution was established at the JKMRC.

This was initiated by Paul Dempsey (Group Head of Metallurgy, Anglo American) and Neville Plint, at the time the Head of Research and Development at Anglo American Platinum in Johannesburg.

In June 2016 Chris Moran resigned as SMI Director to take up the post of Deputy Vice-Chancellor Research at Curtin University. And was succeeded by Neville Plint.

Plint arrived with strong industry experience, a background in flotation chemistry, geometallurgy, process control and extensive knowledge of international and Australian research groups active in the mining and minerals sector gained from his roles within Anglo American.

The completed building was named in honour of founding figure Alban Lynch

Associate Professor Mohsen Yahyaei

He also had known the JKMRC since 1996.

As year 2016 ended, the centre had four defined research programs—Sarma Kanchibotla's Next Generation Mine to Concentrator, Malcolm Powell's Ore Processability, Kym Runge's Predicting Process Performance. The fourth was the newly defined Advanced Process Prediction and Control under Mohsen Yahyaei

The one new product, JKVBOC, which tracks blast movement in open pits, had its origins in JK blast modelling in the 80s, and the pioneering research pursued by Alan Tordoir in simulating 3D blast movement in the mid-2000s. The JKVBOC software development was undertaken by Alan Cocker and Mark Jones when they were part of BRC. It is a great example of commercialisation sourced from another SMI centre but such links have been uncommon.

The longevity of JKSimMet is remarkable, with 190 systems delivered over the decade. So also is the drop Weight Tester with 43 sold in the 2010s, and more than 70 sold worldwide by 2020. JKVBOC has been rolled out across four mine sites 'so far' / 'and growing', all proof that there is a market for quality products.

IN SUMMARY

In terms of judging technical achievements, this will always be subjective, but some advances stand out.

These are the ones which began with genuinely new research topics and resulted in new technologies which have had lasting impact on the industry.

The list of achievements started with the modelling, simulation and control of mineral processing and coal preparation operations.

The modelling work has influenced the optimisation and design of plants worldwide and its impact cannot be overstated. The comminution models, embodied in JKSimMet, and the associated methods for assessing the potential for rock breakage, are now international standard techniques.

At the time of writing JKSimMet has sold well over 500 copies over 35 years, an extraordinary record of longevity and volume for a piece of software with an inherently highly specialised market. Its sibling, JKSimFloat has similarly changed the way flotation circuits are designed and optimised, using a unique plant surveying protocol with sampling devices developed specifically for the purpose.

Chris Wood's dense medium cyclone (DMC) model, developed in his PhD, is now the industry standard for the simulation, optimisation and design of DMCs for coal preparation.

Next in chronological order was blasting technology. The centre knew absolutely nothing about blasting when it began the work in the 70s but was unperturbed.

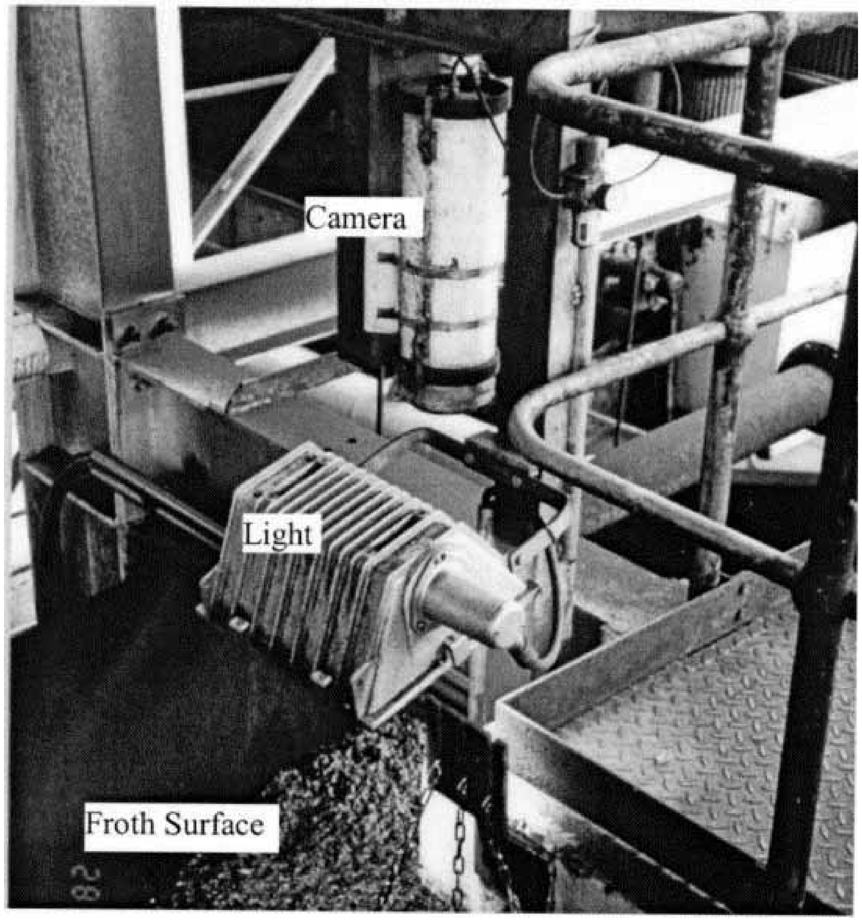
The industry recognised a need, and through AMIRA, blasting research grew to be the largest industry funded project in any University. The project made many advances, especially in the development and application of novel instrumentation, but most of all, it served to galvanise the focus of the mines and the explosive suppliers to make blasting practice more scientific and effective. The blasting work also provided the background for two subsequent important research topics, and generated the blast simulator JKSimBlast, which has now sold more than750 copies worldwide.

The development of ore specific breakage functions in the early 80s along with a set of breakage testing machines and procedures which followed was a breakthrough for comminution modelling. These have been adopted as standard methods around the world. This development was also the first step in ore characterisation, which became a theme in many subsequent projects and directly links to geometallurgy 20 years later.

The AMIRA Fine Grinding Project of the early 1990s was the first major successful collaborative project undertaken by the JKMRC.

It was with CSIRO and what is now the University of South Australia, and developed the first understanding of the effects of fine grinding on flotation through novel measurements.

Chris Wood's dense medium cyclone work became the prototype for much to follow



The JKMRC has pioneered many of the techniques needed for productive collaboration over the years, leading up to the present global comminution collaborative involving universities in six countries.

The Mineral Liberation Analyser (MLA) earns a place as perhaps the most important development because of the way it transformed the use of automated mineralogy by the industry. The JKMRC initiated a project with CSIRO in the latter 70s which resulted in the QEM*SEM system. JKMRC's MLA development in the late 90s produced competition in the marketplace and the associated bureau service developed on the back of the MLA. Although the MLA was sold in the mid-2010s, the JKMRC still operates an active MLA laboratory that services both research and commercial analysis needs to this day. But its real legacy is that sophisticated quantitative process mineralogy is now relatively routine rather than being a slow and exotic technique not widely used.

The JKMRC and the CODES unit within the University of Tasmania can jointly claim to have put the concept of geometallurgy on the map through the AMIRA GEM project which commenced in 2005. Within the JKMRC, GEM had its foundations in the ore characterisation work which began in the 80s and the MLA which allowed mineral liberation to be studied and quantified and linked to comminution and flotation models. Geometallurgy has now become a mainstream tool for the industry.

The early 2000s were an extremely productive time for equipment and instrument development. JKFrothCam was being installed in coal and processing operations and providing important cash flows for JKTech.

It, and subsequent specialised research and products, have allowed the JKMRC to maintain its place at the forefront of global conversations around excellence in mine operations.

CHAPTER 5

HELPING ADVANCE AUSTRALIA

MINING STUDIES AROUND THE NATION

Since the early days of the industry, mining and minerals education had been taken seriously by mining managers across Australia.

There were Schools of Mines established at major centres of mining in every state as early as 1903.

As mining and metallurgical education moved to universities in Adelaide and Melbourne, and later Sydney in the 1920s, those close connections with industry were maintained.

As well as educating undergraduates, universities were actively involved in research. Those within industry often brought technical problems to the universities for solutions.

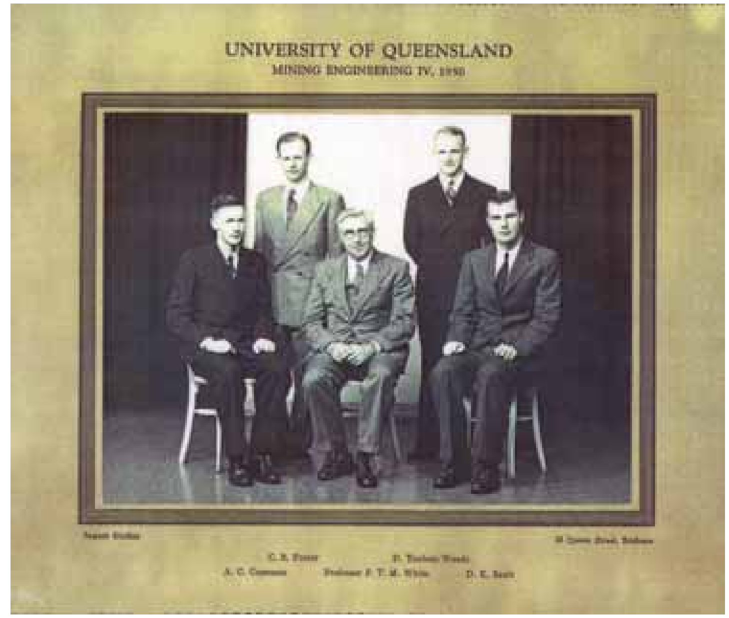
A tradition of practically-focussed research and development had been established over the first century of mining in Australia and industry and universities were partners in problem solving.

RIVALS WHO SAW SENSE IN COOPERATION

It has been remarked that the Julius Kruttschnitt Mineral Research Centre (JKMRC) emerged at exactly the point in time it was needed for the Australian mining scene.

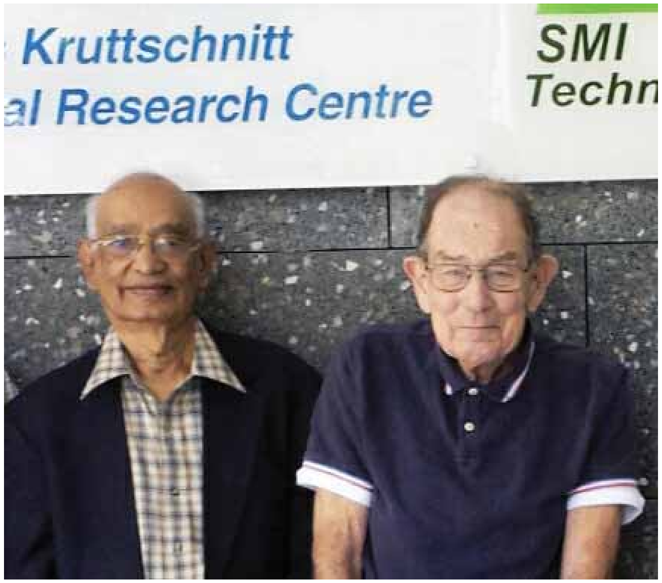
In the 1950s the domestic mining industry expanded under the direction of leaders who saw the value of research and development.

The mining companies were at times commercial rivals, but they had the good sense to collaborate on funding high quality research to solve technical problems for the industry as a whole.



Those involved in Mining Engineering at UQ in 1950

How the number of graduates from the school had grown within 10 years



TC Rao and Alban Lynch

The minecart used to ferry underground workers in Mount Isa

In 1959, they joined together to establish the Australian Mineral Industries Research Association (AMIRA) to fund cooperative industry research.

The industry has been a strong partner of the JKMRC since the Project P9 started in 1962.

Enlightened industry leaders embraced the Lynch concept of practical research with readily applicable outcomes in operations.

The industry provided the funding and the mines and plants for experimental work and employed the graduates.

Actually, it was the industry – operating through AMIRA – which was the key. The AMIRA concept of industry jointly funding research and sharing outcomes perfectly fitted the JKMRC model developed by Alban Lynch.

Jim May, the first full time leader of AMIRA, and Lynch formed an unbeatable partnership which moved to embrace international companies from the earliest times.

ASTOUNDING ACHIEVEMENTS

Clearly, the successes of the early Project P9, both technical and methodological, were enough to impress AMIRA which, in late 1964, renewed support for a three-year extension of the project with increased funding.

Impressed by the hard work of Alban Lynch and TC Rao, Mount Isa Mines agreed to pay Lynch's salary and provide a grant for equipment at the Indooroopilly pilot plant, so different concepts could be tested in advance of arrival in Mount Isa. For the first time, the 1965-67 project would embark on process control studies in plants.

So, the pattern was set – postgraduate students spent months at remote plants collecting data for thesis projects. It all looked disarmingly basic.

But this unassuming project would astound the research community with its achievements, and with its longevity.

P9 has continued for approaching 60 years, and its early success formed the basis of what would become – in less than a decade – the JKMRC on the site of the UQ mine in Indooroopilly.

A residential school, known as the Winter School, was offered by the JKMRC to explain the new modelling and simulation techniques to metallurgists from sponsor companies of P9.

Lynch understood the need to disseminate research results to industry, and Winter Schools were held for many years, attracting interest from both domestic and international entities.

A HEAVY LINK TO MOUNT ISA

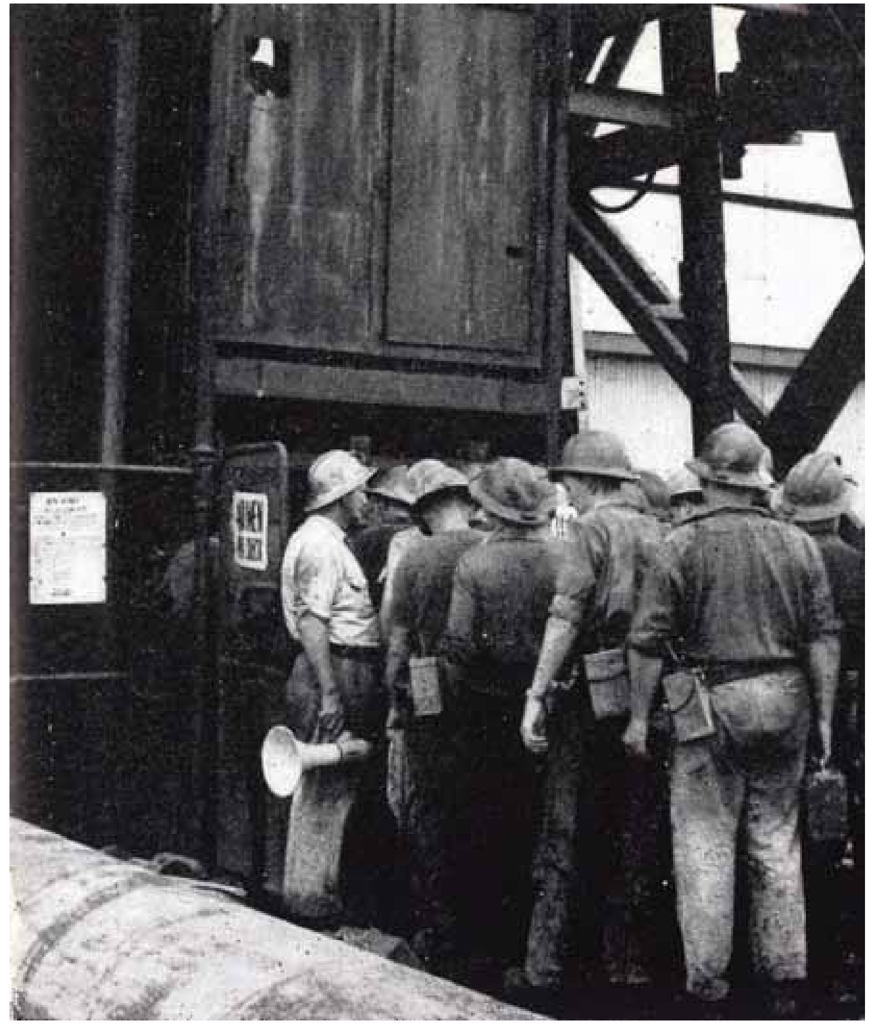
Countless companies have supported the JKMRC, but the most important was Mount Isa Mines Ltd (MIM).

MIM's Jim Foots wrote in enthusiastic support of the first AMIRA proposal in 1961. The company also provided the opportunity for ground breaking early researcher TC Rao to conduct the first site work of the project and the majority of his site work opportunities.

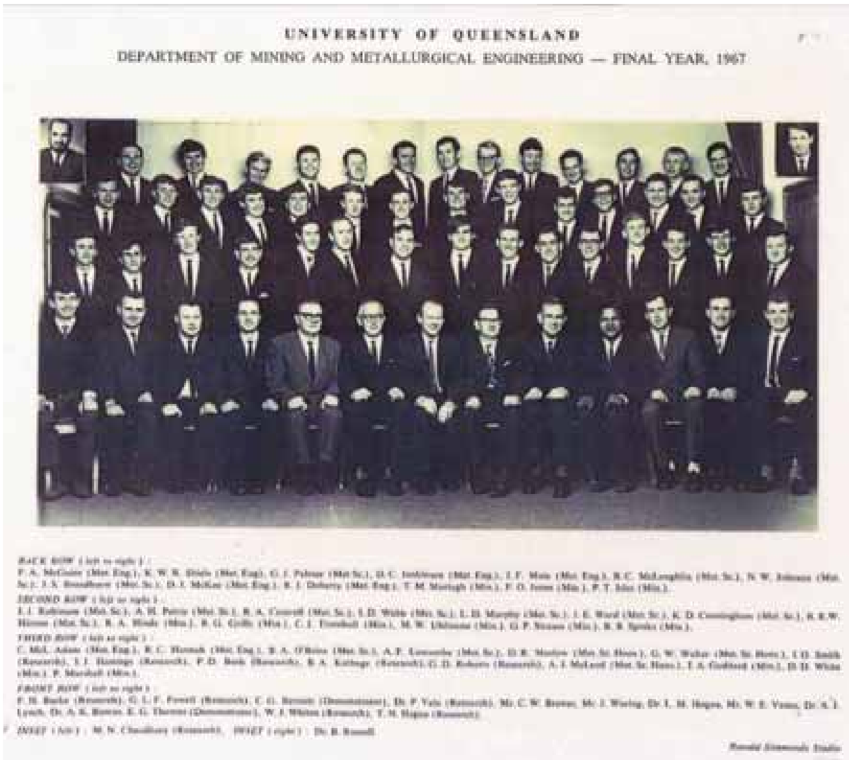
Simulation using newly developed models was first successfully applied to a MIM grinding circuit and the JKMRC's first crushing, grinding and flotation trials were conducted at MIM.

It was Foots, as Chairman of MIM Holdings, who later convinced the company to back the transition of Alban Lynch's research group to the JKMRC in 1970, named in honour of Julius Kruttschnitt, himself associated with MIM.

It was MIM that funded the first two decent buildings at the Indooroopilly mine site.



Workers prepare to go underground at Mount Isa Mines



The 1967 Department of Mining and Metallurgical cohort included Alban Lynch and Bill Whiten as teachers, and Don McKee among the graduates

Furthermore, Cliff Williams (MIM General Manager - Research) was largely responsible for the continuation of the annual $75 000 grant for over 25 years.

A PIPELINE OF TALENTED MINDS

Many University of Queensland graduates were enticed to later join the JKMRC as postgraduate students thanks to a strong engagement program.

However, it wasn't necessarily an intentional consequence to begin with, when Alban Lynch and Bill Whiten took over teaching a final-year mineral processing course at UQ in 1967.

For decades to follow, researchers from JKMRC would deliver modelling, simulation and control courses to UQ undergraduates.

This expanded in the late 1980s to include the final year design course for mineral processing students.

The interaction and shared experiences of the undergrads brought about a lasting trend of them developing an interest in the JKMRC and dedicating their energies there after graduation.

EXPANSION TO FURTHER FIELDS

In 1967, research was extended to interstate plants and to matters concerning automation of process control.

When grinding circuits were sampled at New Broken Hill Consolidated (NBHC), subsequent simulation indicated that rearranging the circuit could improve throughput and provide better feed sizing for flotation.

Both predictions proved accurate, and validated results from MIM the previous year.

The work at NBHC resulted in the first project review meeting, an informal affair conducted while work was in progress.

Metallurgists from the other Broken Hill companies and from Cobar – all project sponsors – attended. From that time, project review meetings became a standard feature of P9 and other AMIRA projects.

By the late-1960s, the JKMRC template was firmly established, and the principles of industry-based research led by post-graduate students – grounded in firm objectives, problem-solving and practical and academic rigour – were widely accepted and admired by leaders of the mining sector.

FOUR MORE TOPICS OF INTEREST

Funds provided by Mount Isa Mines created an opportunity for the JKMRC to explore new research ideas of potential impact to Australia's mining industry resulting in the JKMRC branching into four new research topics:

1. Instrument development for measuring pulp and froth characteristics
2. The effect of the chemical environment on flotation kinetics
3. A study of the flow of ore through the mine and mill – an early mine-to-mill concept
4. A study of the potential for simulation of smelting processes.

The first two areas were pursued in the early and mid-70s.

While the instrument work was encouraging, it was a support activity. Lynch required a new project and it was coal preparation which eventually took the centre in a new direction (see the following chapter: *International Impact*).

It was not until the early 1990s that mine-to-mill concepts were seriously pursued, while the smelting work has only recently been added to the JKMRC's capabilities.

Preserved headframe at Broken Hill

Professor Tim Napier-Munn

COMBINING POWERS

The team at the JKMRC understood that collaboration could be successful and many scientific outcomes and practical developments were applied on site in sponsors' plants.

The design of the project under the AMIRA umbrella meant the reputations of the research participants were also at stake, which was a powerful motivator.

The participants learned that collaboration under well-managed terms was enjoyable and technically rewarding. The methods developed by Tim Napier-Munn to bring disparate groups together became a template for how to conduct collaborative projects.

The Collaborative Research Centres (CRCs) worked differently. The CRC system was designed to create strong links between research and industries across the board.

A senior CSIRO executive told Don McKee that the JKMRC served as a template for the CRC planning in Canberra. CRCs suggested a means of accessing significant government funds – something which had eluded the JKMRC until that time.

CRCs would be awarded on a competitive basis with first round submissions due in early 1991. Proposals had to demonstrate the involvement of at least two research partners from different institutions and industry.

Lynch, then at the department, and people from MIM came up with the notion of an equipment-based CRC concept, with large mining equipment as a focus. This had little appeal to the JKMRC at the time, but the centre was struggling to develop an alternative concept.

The breakthrough followed one of McKee's regular Friday morning discussions with Dean of Engineering Ted Brown, who said the JKMRC management team had to go away for a couple of days and come back with a CRC outline. He offered use of the Dean's conference room at St Lucia.

Don McKee, Rob Morrison, Andrew Scott and Tim Napier-Munn took less than a day to develop a CRC concept on the theme of rock breakage leading to equipment outcomes. Most importantly, it was a concept that required fundamental science.

It was a good idea, but it required two partners, the industry and another research group. The industry involvement was readily solved.

McKee spoke with Jim May who agreed, subject to his council's approval, that AMIRA would act as the industry partner. No funding commitments were sought through AMIRA at the time.

The proposal stated that the CRC partners stood on their record of industry funding and that industry would come good as projects developed. This was audacious and would not be acceptable today.

The question of the research partner was a different matter. One group stood out – the CSIRO Division of Geomechanics, led by Bruce Hobbs.

This meant forging a relationship with CSIRO, with a division and people quite unknown to the JKMRC. The centre was nervous but, the task proved painless.

McKee put the proposition to Hobbs who accepted on the spot. Development of a proposal for a Centre for Mining Technology and Equipment (CMTE) was a massive task, but the effort was rewarded when the CMTE was selected as one of the first-round CRCs.

Champagne flowed at the centre when the announcement was made. McKee remembers the occasion as one of the highlights of his JKMRC years.

The CRC was to bring both pleasure and pain to the JKMRC in the years ahead, but it paved the way for the centre's involvement in more CRCs.

The JKMRC embraced the research opportunities presented by the CMTE. Scott undertook an extensive review of research needs in mining to identify industry priorities, the first such study by the JKMRC.

Dr Bruce Hobbs

The former CSIRO headquarters in Canberra

Hewlett Packard advertisement for computers of the era

New research into the modelling of mineral textures was initiated by Lyman. The fledging mineral processing program of CMTE was managed by the JKMRC.

EVERYONE LOVES A NERDDC

A new system for funding coal-related research emerged in 1978, when the Australian Government established a mechanism for funding research by placing a levy on coal production.

The newly established National Energy Research, Development and Demonstration Council (NERDDC) was a boon to the JKMRC, as the centre could apply to one central body to fund projects of interest to the coal mining industry.

NERDDC was fundamentally different from the AMIRA approach, where the metalliferous industry had rebuffed any suggestion of a levy system for supporting research.

The JKMRC became as proficient in using NERDDC as it had been with AMIRA.

COMPUTERISING AUSTRALIA'S PLANTS

As P9 marched onwards process control demonstrations in plants became a priority.

In 1972 the centre acquired an HP2100 computer, more powerful and much smaller than the first PDP8 machine.

It was taken to many plants around Australia, in the process demonstrating the power of digital computer-based control. Chris Bailey rapidly became an expert in process control and in installing the HP2100 in plants.

Emmy Manlapig, a student from the Philippines, spent many months at the new No 4 Concentrator at MIM developing flotation control systems.

Elsewhere, Geoff Stanley's autogenous mill modelling was built upon by Geoff Gault – who worked in the Kambalda Nickel concentrator of Western Mining and at Savage River in Tasmania – and Geoff Duckworth – whose experimental work was conducted at the Henderson operation of AMAX Inc in Colorado, the Pinjarra alumina refinery in Western Australia, and St Helena in South Africa.

FLOTATION GOES TO ANOTHER LEVEL

The early flotation work of Bill Johnson, Don McKee and alumnus number 14 Robert Cuttriss was followed by Grant Thorne who spent months at Zinc Corporation working on lead-zinc flotation.

Thorne identified the challenge posed by composite particles to flotation modelling. Simple assaying techniques gave no information on the degree of liberation of particles.

The problem of composite particles had been known for decades – indeed it had confounded metallurgists at MIM from its earliest operation in the 1930s.

The only method for assessing composite particles was microscopy examination by experienced mineralogists. This approach was slow and tedious and very few companies had mineralogists on site. This all changed when JKMRC research led first to the QEM*SEM and then the MLA, by which time much of this tedious work was completed automatically.

A modern flotation circuit

UNBLOCKING A BOTTLEKNECK

Located in the remote northeast of Western Australia, the Argyle mine in the Kimberley region was for many years the largest single producer of diamonds.

Over 90 per cent of the world's rare pink diamonds were produced in the Kimberley.

The Argyle Diamond Mine

Alban Lynch took another leap into the unknown when the company CRA was in the process of designing the treatment plant for the Argyle Diamonds operation.

At Argyle's request, the JKMRC committed to develop a full dynamic simulation of the plant, so potential bottlenecks could be studied along with process control requirements.

Geoff Lyman and Carol Smith successfully undertook the task. Smith's PhD studies were interrupted to tackle this new assignment, a turn of events that was not uncommon at the centre.

In those days students accepted the practice, as it invariably led to very useful experience, but it would probably not be accepted today, when students are obliged to work within a tight timeframe to finish their theses.

NOVICES WHO IMPRESSED

It is fair to say that many of the Australian mines which conducted blasting experimentation had initially regarded the JKMRC team as novices.

They were perceived as a group who were learning on the spot, and some suspected they didn't have a lot to offer.

Nonetheless, the industry appreciated their willingness to have a go, and undertake work which the mines had not.

The attitude of the industry rapidly changed as it became clear that the JKMRC approach was working, and providing information which had not been previously available.

From the outset, the blasting project was concerned with both underground and open pit blasting in metalliferous mines supported by P93 and open cut blasting in coal mines funded by NERDDC.

Mount Isa and Broken Hill saw a lot of the initial underground work and Hamersley and Mt Newman featured strongly in open pit work.

The Bowen Basin and Hunter Valley mines were the initial test sites for coal related blasting.

UNKNOWN TERRITORY

A regular feature of the Alban Lynch approach was to take risks by venturing into unknown territory.

The blasting project was the foremost example, but there were other smaller ones, such as when oil shale deposits in Central Queensland were all the rage.

Southern Pacific Petroleum sought help to examine the use of mineral beneficiation methods to upgrade mined shale, prior to resorting for oil recovery.

The JKMRC turned to UQ Metallurgical Engineering graduate Graham Walter, who over a two-year period conducted a systematic study of many beneficiation methods in the pilot plant, assisted by Tim O'Brien as a Masters student.

Tragically, Walter lost his life in a car accident before he had written the final report. Don McKee took over the task, one made easier by the meticulous way in which every step of the project had been recorded.

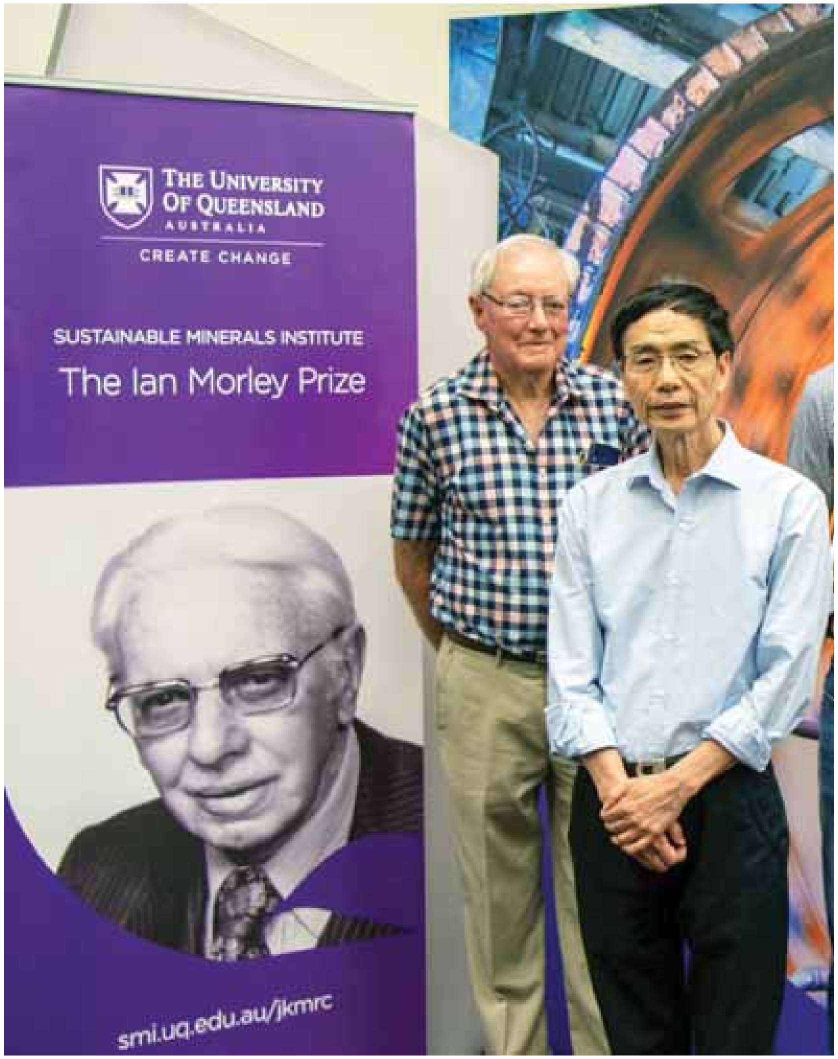
WORTH THEIR WEIGHT IN GOLD

As the student numbers increased at the JKMRC, so did the opportunities for them to find work in industry.

Because they were graduates who had developed a liking for industry, they were highly employable.

Don McKee became used to fielding calls from companies wanting to know who was about to emerge from the JKMRC training pipeline. Some companies placed higher value on the people trained at the centre than on the research outcomes.

Map of oil shale deposits in Australia



Professors Don McKee and Frank Shi attend a presentation of the Ian Morley prize

From the late 80s, the JKMRC developed a strategy to increase student numbers. The 30 students of the late 80s had grown to more than 50 by the mid-90s.

Some of them were industry people undertaking external study.

Such a large group deserved special recognition and three events emerged during the 90s—the Ian Morley Prize, the Postgraduate Student Conference and International Night, at the time of writing all these events still continue.

This period also saw the establishment of the JK Jackals, the JKMRC postgraduate cohort's social group that is still active.

Ian Morley was a widely respected friend of the JKMRC, a former state mining engineer and chief inspector of mines whose career had spanned more than 60 years in the Australian mining industry.

After his retirement in 1969, he began a much closer relationship with the JKMRC, as a research associate and regular participant in the Friday seminars. His research into the history of the Australian mineral sands industry resulted in the publication of *Black Sands* in 1981.

A LENGTHY ASSOCIATION WITH THE CSIRO

The JKMRC was active with P9 flotation control trials in the early 1980s.

Carol Smith was running experiments at Zinc Corporation and Mount Isa Mines, Don McKee and David Wiseman were at Cominco, Andrew Thornton was at Bougainville, while Mike Casey was at Renison.

It was the latter work of Casey which resulted in the gradual development of collaboration with CSIRO. Previous associations had not exactly flourished for the long-term.

Lynch had some connections with CSIRO's Denis Kelsall at the time of Rao's work. Kelsall had done pioneering work in the study of cyclones in the 1950s and some of his concepts were used in the JKMRC cyclone model.

However, Kelsall and Lynch had very different personalities and approaches to modelling, with Kelsall concentrating on laboratory studies while Lynch focused on plant experimentation.

They did not see eye-to-eye, best illustrated with a confrontation over the content of a technical paper at an AusIMM conference in 1971. Those who were in the audience never forgot the encounter.

The next CSIRO association was between Alan Reid and his staff and John Hall which resulted in the development of MINSCAN.

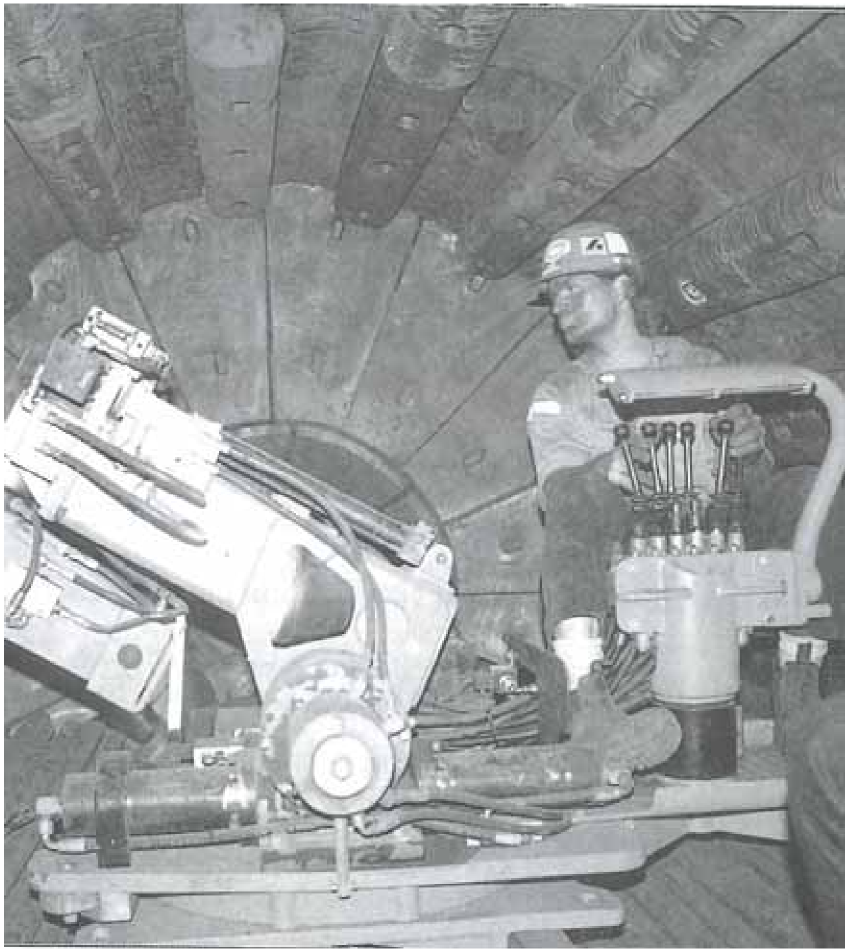
This collaboration was extremely successful but it did not continue after Hall completed his PhD, although the centre became a user of the system. Geoff Lyman also had a productive association in the early 80s with Brian Sowerby of the Atomic Energy Commission, and later the CSIRO Division of Mineral Engineering, but again the link ended at the completion of the project.

In the early 1980s McKee met David Sutherland and John Frew, two highly competent and friendly members of the CSIRO Division of Mineral Engineering.

They were both working in similar areas on aspects of P9, flotation (Frew) and process control (Sutherland). Sutherland happened to work at the Renison concentrator in Tasmania at the same time as Mike Casey, who was to undertake a flotation control study.

Sutherland agreed to jointly supervise Casey and keep an eye on his work at the concentrator. This proved to be a very successful arrangement: It demonstrated that JKMRC and CSIRO could work together. The friendly association with Frew and Sutherland was maintained by Tim Napier-Munn, then a Research Project Manager, and was to become critical to the establishment of the AMIRA Fine Grinding project in 1990.

A later model of MINSCAN



A mill relining machine operating inside a rod mill

FINE GRINDING

By the mid-80s it was clear that very fine grinding, well beyond the scope of ball mills, would be necessary if some of the fine-grained lead-zinc ores were to be processed economically.

The AMIRA Fine Grinding Project (P336) was conceived in late 1989 and early 1990 to develop an understanding of regrinding in base metal flotation circuits and to review the potential of new fine grinding technologies. The project ran from late 1990 to early 1994 and was managed by JKMRC. A smaller renewal was managed by CSIRO.

The project was the first serious collaboration between JKMRC, CSIRO Division of Minerals and the University of South Australia (then SAIT) – a development welcomed by the industry. Eleven companies sponsored the project and extensive plant surveys were conducted at the Mount Isa and Hilton mines (MIM), Elura (Pasminco), Hellyer (Aberfoyle), and Red Dog in Alaska (Cominco).

Three topics were studied – investigation and modelling of existing fine grinding processes (mainly tower mills), impact of fine grinding on flotation, and new fine grinding technologies. The project also led to enhancements for CSIRO's QEM*SEM and to a review of fine particle measurement techniques.

STAGE THREE DONE

The completion of Stage Three of the JKMRC buildings occurred in 1993. The relief was almost tangible, particularly for the mining group who had been housed in demountable buildings.

The new building included a 100-seat lecture theatre and was the first to be fully air-conditioned. It had not been achieved easily.

Ted Brown, by now Senior Deputy Vice-Chancellor, convinced the University to fund construction, on the condition that the JKMRC paid back the costs at the rate of $120 000 per year.

McKee, in turn, persuaded Lynch – in his last year as Head of Mining and Metallurgical Engineering at UQ, where he spent the years 1989-93 after moving on from the JKMRC – to make these repayments from the approximately $700,000 the department received annually from the research activities of the JKMRC. The department kept the rest.

BLASTING IN THE 90s

One of the most significant achievements in the early 1990s came from the blasting project.

Somehow, the new team which Scott had developed since 1988 managed to deliver the full set of outcomes promised in the 1987 P93 proposal. This required a monumental effort from the team which had grown to 18 staff and 23 students.

The effort left the team exhausted. Never again would the JKMRC be responsible for a project which serviced the requirements of 31 operating companies, some with multiple designated sites, and four explosives suppliers. The blasting team in Chile also had to be supported.

Leadership of the project passed to Steve Hall, Bill Adamson and finally Andrew Tunstall, the venture came to an end in 1994 as P93 wound up.

The establishment of the Sustainable Minerals Institute meant exciting new areas of collaboration

ESTABLISHMENT OF THE SMI

One of the biggest revolutions to the visage of the JKMRC came with the establishment of the Sustainable Minerals Institute at The University of Queensland in 2001.

The SMI came about as a proactive response to the commissioning of the Mining, Minerals and Sustainable Development Project in 2000, an initiative of the World Business Council for Sustainable Development.


The physical home of the Sustainable Minerals Institute

The Council itself was formed of more than 20 international mining companies, commercial sponsors and non-commercial interested entities.

UQ put a strong proposal forward to the Queensland State Government that the state could be a leader in expanding minerals-related research and addressing wider social and sustainability challenges facing the global resource industry.

Consequently, the State Government committed to an award of $10million for the establishment of the SMI, with JKMRC combining with three other centres to initially comprise the new body.

The other centres were the WH Bryan Mining Geology Research Centre, the Centre for Mined Land Rehabilitation, and the Minerals Industry Safety and Health Centre.

This was later expanded to include the Centre for Social Responsibility in Mining, the Centre for Waters in the Minerals Industry, and the International Centre of Excellence in Chile (SMI-ICE-Chile), the latter of which is referred to further in the *Global Impact* chapter.

The JKMRC, as the oldest centre within the institute, was in many ways the jewel in the crown of the SMI and maintained its proud history of ground-breaking endeavours under the new structure.

An ACARP project to study the barriers to high-capacity long-wall mining, involved Gideon Chitombo (SMI), Bob Trueman (JKMRC), James Joy (MISHC), David Brereton (CSRM) and Chris Moran (CWiMI).

This cross-disciplinary project involving contributions from multiple SMI centres demonstrated what could be achieved in new research by linking the centres.

UNDERSTANDING URANIUM

The year 2006 brought the first successful multi-centre project for the Sustainable Minerals Institute (SMI), Ironically, the first project was not for the industry but for the Queensland Government.

It was a study to investigate the impact of potential uranium mining in Queensland on the state's export coal industry.

Uranium had long held an enigmatic identity on the state's – and nation's – list of resource considerations, given its decisive public profile.

The study involved SMI centres and the Business School, under the direction of Tim Napier-Munn.

Longwall mining, Credit - Markus Schweiss

CHAPTER 6

A GLOBAL IMPACT

SPREADING THE PROJECT'S WINGS

Alban Lynch's vision and abilities were not only admired on a domestic stage.

When it became apparent that his specific expertise filled a void elsewhere, word spread quickly within the international mining community.

The head of metallurgy at the Colorado School of Mines in the USA, Professor Al Schlechten, travelled to The University of Queensland in 1966 to learn about the new modelling and simulation techniques being pioneered.

Back then it was known as 'winter school', but would be termed 'technology transfer' in modern times.

Professor Schlechten urged Lynch and his colleagues to present the course in Colorado in 1967, marking the start of Project P9's international profile.

Rex Bull, a lecturer with experience teaching mineral processing at UQ, joined the Colorado School of Mines in the same year, and was actively involved in the course.

The success of the course was no doubt aided by the connection to prominent P9 partners Mount Isa Mines, of which American entity ASARCO was the parent company.

A major copper producer in Arizona, ASARCO had an acute awareness of Lynch's past successes.

The Colorado School of Mines and the JKMRC were early to conduct knowledge exchange

An open pit mine in the Philippines, in Cebu

"There was then no work like Lynch's in North America," remarked Don McKee.

Having the support of ASARCO counted for much in growing an international reputation.

Lynch recognised that the minerals industry was international in nature and was keen to forge wider links. He loved visiting international operations and universities and remained an enthusiastic international traveller for over 50 years.

SUMMER OF '69

He was only 21 years of age, but Bill Johnson staked an early place in history for the Julius Kruttschnitt Mineral Research Centre.

In response to a pressing problem, Johnson was sent on a plane to the Philippines – becoming the first JKMRC student to travel internationally on official duties.

The feat was made even more commendable by the fact that none of his colleagues had ever visited the Pearl of the Orient themselves.

Persistent problems had plagued Johnson's flotation research before his departure, a reflection of the complexity of Australian ores.

One of Lynch's industry colleague suggested sending the student to the Philex mine in the Philippines, where ores were more suitable to the research.

Johnson was said to have performed a great job on his sudden journey into the unknown, and fellow students were envious of his experience.

The trip marked the beginning of a vibrant period of international study and exchange involving JKMRC personnel.

LEAVING BY EXAMPLE

In 1971 Alban Lynch did something which could have been seen as risky, yet it eventually turned into a time-honoured tradition.

He left.

More specifically, Lynch took a year away from the JKMRC to be based with a University abroad.

He relocated to the University of Minnesota in the mid-north of the USA, housed in their Department of Mining.

On his return to the JKMRC he espoused the benefits of weekly seminars so that students who had been away working could share their research progress.

Because everyone working at the centre had a passionate interest in their work – otherwise they would be working somewhere easier – the quality of the seminars was exceptional.

The seminars became an integral part of students' lives and professional development and they still run every Friday morning at the Centre, with the only difference being that they are now broadcast live on the internet and regularly attract hundreds of attendees from around the world.

A lifelong fascination for exploring new places and meeting new people saw Lynch venture to East Germany, Russia, Chile and China during the 1980s.

Lynch's visit to Freiburg University, then in East Germany, resulted in a reciprocal visit to the JKMRC by Professor Heinrich Schubert.

Schubert's lectures in turbulence caught the imagination of Canadian Geoff Lyman, who had supervised Trevor Nicholson's Master's thesis on turbulence effects in flotation.

Professor Oleg Tikhonov, from the St Petersburg Mining University, likewise spent a period at the centre.

Casa Central at the University of Chile

Lind Hall at the University of Minnesota, where Alban Lynch relocated

A frequent visitor was Professor Guillermo Gonzalez, a process control expert from the University of Chile in Santiago.

These visits by people from very different countries and political systems did a lot to open the eyes of JKMRC staff and students to the wider world.

UTAH DEVELOPMENT COMPANY

Once again impressing a force in American mining, the JKMRC was able to forge a strong relationship with Utah Development Company in the centre's early years.

Now known as BHP Mitsubishi Alliance, Utah Development Company had a high level of interest in Bowen Basin at the point at which it was rapidly developing.

Journalist Ron Scherer once called the company 'The Mine King' and by 1981 he detailed they were operating 22 giant draglines, worth $400 million, with a total investment in Australia of $800 million.

Indeed, by the 1980s they were exporting 25 per cent of the coal mined in Australia, representing a subsidiary operation of the all-powerful multinational General Electric.

Utah Development Company was particularly intrigued by the JKMRC's early work on improving coal preparation efficiency.

Deciding to fund the centre to run a feasibility study at Peak Downs mine associated with flotation, Utah Development Company was effectively signalling a vote of confidence.

Following the success of that study, Utah funded a major investigation of coal flotation and a new team was formed for the work.

Geoff Lyman, a Canadian chemical engineer from McGill University, joined Cameron McKenzie, a metallurgical engineering graduate from UQ.

Two JKMRC students, Bob Leach and John Thompson, joined the group, along with Rob Chesher, who subsequently was employed by ASARCO in Arizona. This was the start of the coal preparation group within the JKMRC.

Canadian Lyman was a man of outstanding intellect. He possessed the rare ability to be able to tackle completely new topics from a first principles approach.

Working within the Utah coal project, Lyman set to work to develop techniques to measure the ash content of streams in coal preparation plants. This was the first of many developments undertaken by Lyman over the coming years.

With the Utah project, the centre showed it could find new sources of funding – particularly from overseas entities with a stake in Australia – if it applied its operating principles to diverse problems of the industry.

RAO RETURNS

In the mid-70s, Tadimety Chakrapani Rao returned to the JKMRC for six months. He was a trendsetter in more ways than one.

Rao had been the first international student and the first to undertake extensive field work.

He then became the first technical specialist to spend significant time at the centre, when he continued his work on a large cyclone test rig which had been constructed at the pilot plant.

There has been a steady stream of visiting specialists ever since.

TC Rao (right) has been a central figure throughout JKMRC history

BREAKING DOWN BARRIERS

Xuzhou, where Jon Davis was initially based while researching in China

Lynch's visit to China in 1983 had a lasting impact through the 1980s.

Soon after, he received a letter from Rong Rui Xuan – initially known as Rong and later as Richard Rong during his many years at the centre – requesting a place at the JKMRC.

Rong was a mature-aged coal preparation engineer who had been through the Chinese Cultural Revolution.

Lynch offered him a spot with minimal support. An engaging person, Rong stunned people at the centre with his exceptional work ethic, and even more so when it was revealed that he had left his wife and young son behind in China.

It was several years before the family was reunited in Brisbane.

In 1985 Lynch again visited China with Jon Davis, who was undertaking a PhD within the coal group, to present a series of lectures.

One outcome was that, in 1986, Davis moved to China as a National Research Fellow, initially based in Xuzhou, with the brief to develop joint JKMRC- China research activities. That was a tough year for Davis as he was exposed to a completely foreign working and social environment.

One of his first activities was to investigate a possible project in a Chinese non-ferrous operation. Out of this came a process control project at the Fan Kou lead-zinc operation, the first process control system in a Chinese concentrator. The work was done by Bill Whiten and Toni Kojovic.

In later 1986 Davis moved to the Bejing Graduate School where he became a senior engineer within a coal-water mixtures project, a role that continued till early 1988, when he returned to Brisbane.

One of the positive results of his time in China was the arrival of over a dozen students and trainees to the centre up to 1989. These students were bright, highly motivated and added a great deal to the cultural life of the JKMRC. They also delivered excellent technical work across all areas of centre research.

One of them, Frank Shi, went on to become a professor within the JKMRC. The Tiananmen massacre of 1989 effectively put a stop to activities in China for some years, but most of the students and trainees would stay in Australia.

A LATIN AMERICAN LIAISON

In 1984 the centre was wrestling with another big idea: the notion of establishing a blasting project in Chile.

Lynch had first visited Chile that year, at the invitation of Ken Findlay, who had been General Manager of Mount Isa Mines in the mid 1970s.

As a result of the visit, McKenzie and two postgraduate students, Jeff Dawes and Bill Adamson, went to Chile in early 1985 to conduct blasting work at the El Soldado mine of Exxon.

They spoke no Spanish – but such things had never been impediments to the centre's way of operating.

What may have been an impediment was the volatile political situation under the government of Chilean president Augusto Pinochet, when street protests, particularly in Santiago, were loud, fierce and punished.

The first foray into Chile was a great technical success — and a personal one for Dawes, who met his future wife on the trip.

Later in 1985, Don McKee and Cameron McKenzie ventured to South America to visit mines in Peru and Chile to ascertain the wider potential for JKMRC.

The Peruvian visits to ASARCO mines at Toquepala and Cuajone did not result in new projects, but they did find Robin Evans and Cathy Evans, two British engineers who joined the centre as students the following year.

A memorial to victims of Pinochet's regime exhibited the volatility of Chile in the 1970s and 80s

Mina de Chuquicamata in Chile

McKee and McKenzie then went to Chile, after a protracted border crossing between the often-conflicting countries, and visited two of the great Codelco mines, Chuquicamata in the north, and El Teniente, south of Santiago.

They witnessed protests in Santiago but simultaneously saw the enormous scope for JKMRC blasting work. Interestingly, McKee did not identify opportunities for P9 type work there at the time.

They also realised that if the centre had serious ambitions to be involved in Chile, it would have to establish a base there, volatile or not. It was a courageous move, but there were no regrets at the decision. Considered risks were part of the JKMRC modus operandi.

A joint venture was negotiated on the spot to support blasting work. CIMM (Centro de Investigacion Minera y Metalurgia) based in Santiago was favoured by the Chilean industry to partner with the JKMRC. CIMM would provide a base and people, while the JKMRC would provide a leader and training for the CIMM staff. Codelco and Exxon South America joined the AMIRA P93 project, and field work at the Codelco and Exxon mines gathered pace.

UNCOVERING A DIAMOND

Founded in 1888, De Beers is a name recognised the world over in mining, operating in more than 30 nations at the time of this book's print.

Having dominated the diamond industry throughout history, they now trade billions of dollars of revenue each year.

It was towards the latter half of the 80s that De Beers recognised the need to improve their blasting practices.

New emulsion explosives and Nonel detonators were introduced into the South Africa mining industry in a sign of these motivations.

"A worldwide search was conducted to identify an organisation which could offer more than a consultant/client relationship, but also offer the possibility of collaborative research as well," said Alan Guest, formerly Chief Geotechnical Engineer for DeBeers.

"The JKMRC was identified as the world leaders in blasting technology and was therefore selected.

"A very productive relationship developed over a period of more than three decades, leading to new avenues of research, with the start of the International Caving Study in 1997 and the Hybrid Stress Blasting Model in 2000.

"A notable outcome of this relationship was the development of JKSplit, a photogrammetric fragmentation analysis program, which was later commercialised by Split Engineering.

"Over the years good personal relationships were established with staff members, and their respective spouses, which still continue to this day."

At the time, the challenging environment of underground South African mines was simply not used to seeing a native-born Zimbabwean as the expert leader of a team of specialists.

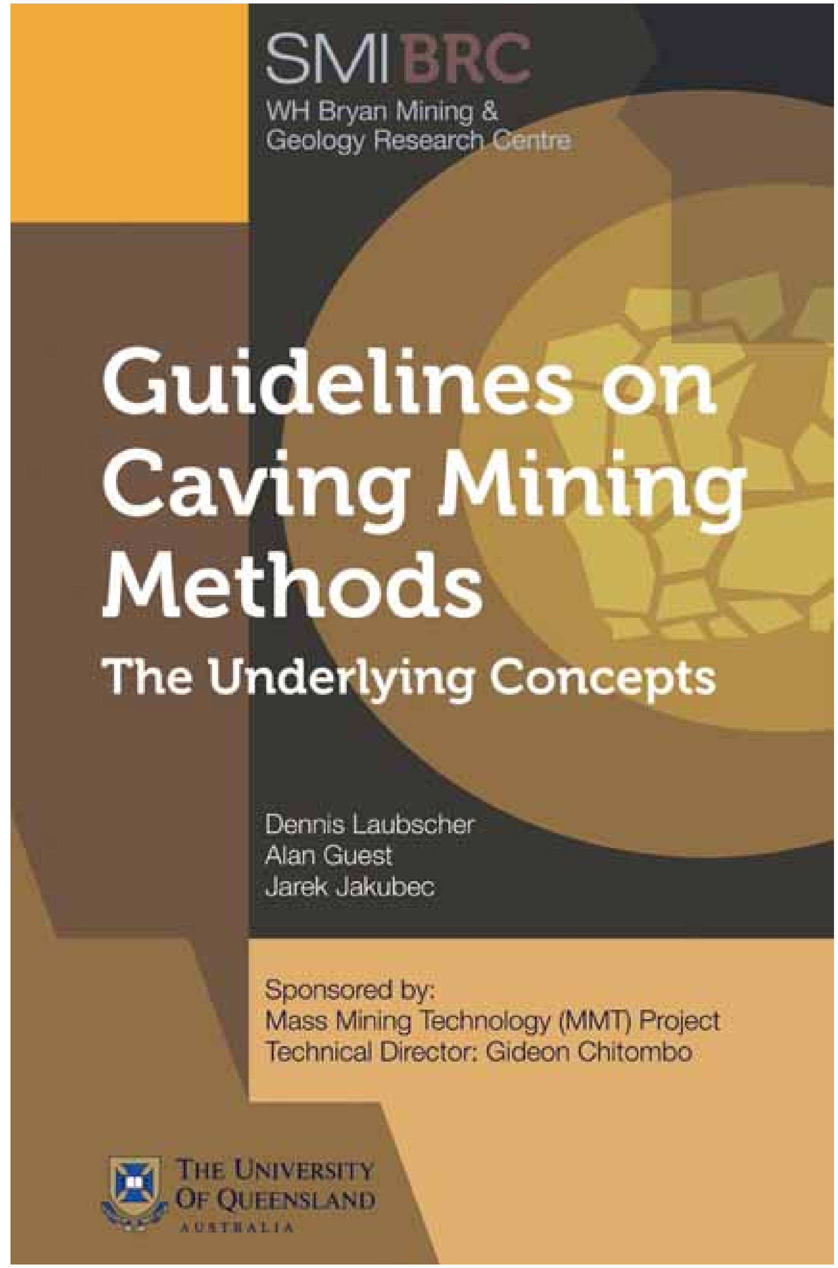
However, as the JKMRC's underground man, Gideon Chitombo led a team to undertake the first blasting project at the Premier diamond mine.

Not only was the project a technical success, it was a minor sensation in other ways. Chitombo's unique personality rapidly had everyone supporting the team.

The Chitombo-Guest association was to be long lasting and of major influence on future JKMRC mining research.

LASTING INTERNATIONAL COLLABORATION

The most successful and long lasting of the JKMRC collaborations was forged with the Department of Chemical Engineering at the University of Cape Town (UCT) in South Africa.



Alan Guest was one of the co-authors on Guidelines on Caving Mining Methods

Professor Cyril O'Connor, Photo - University of Cape Town

The driving force from UCT was Professor Cyril O'Çonnor, then head of the department. Like many of his ilk, O'Connor was a man to spot and act upon an opportunity. He understood the importance of the industry and was very comfortable working with mining companies.

Three years were to lapse before any UCT-JKMRC contact was made – but it eventually happened

The reputation of the JKMRC was well known at UCT in the early 1980s when flotation research activities at UCT began. During that time the Technical Director of Anglo American, Dave Deuchar, frequently reminded people what a strong organisation the JKMRC was and how valuable it would be for South Africa to establish some sort of collaboration with them.

The ice was broken in terms of this interaction in the early 1990s when Tim Napier-Munn visited South Africa to persuade South African mining companies to become involved in the P9 project. At that time UCT had already established strong alliances with most of the major local mining companies which were dominated by the platinum producers. Hence it made good sense for a link with the researchers at UCT.

There is no question that one of the major reasons the two organisations were able to combine successfully was due to personal chemistry and respect established over many years

THE GLUE

One of the key people in building the relationship between UCT South Africa and JKMRC was J-P Franzidis.

J-P had a wonderful gift of getting on with everyone he met. The South African national went to spend a sabbatical at the JKMRC shortly after Tim Napier-Munn's visit in the early 1990s and this consolidated the collaboration.

Fulfilling a similar role was the JKMRC's Steve Morrell, who acted as a fantastic mentor to the UCT group in developing capacity in comminution.

Another to play a key role was the late Dee Bradshaw, who had a remarkable ability to build networks, and eventually took up a position as a Research Professor at the JKMRC.

She later returned to South Africa to occupy a position as the Director of the Minerals to Metals Initiative, which had been launched by J-P Franzidis.

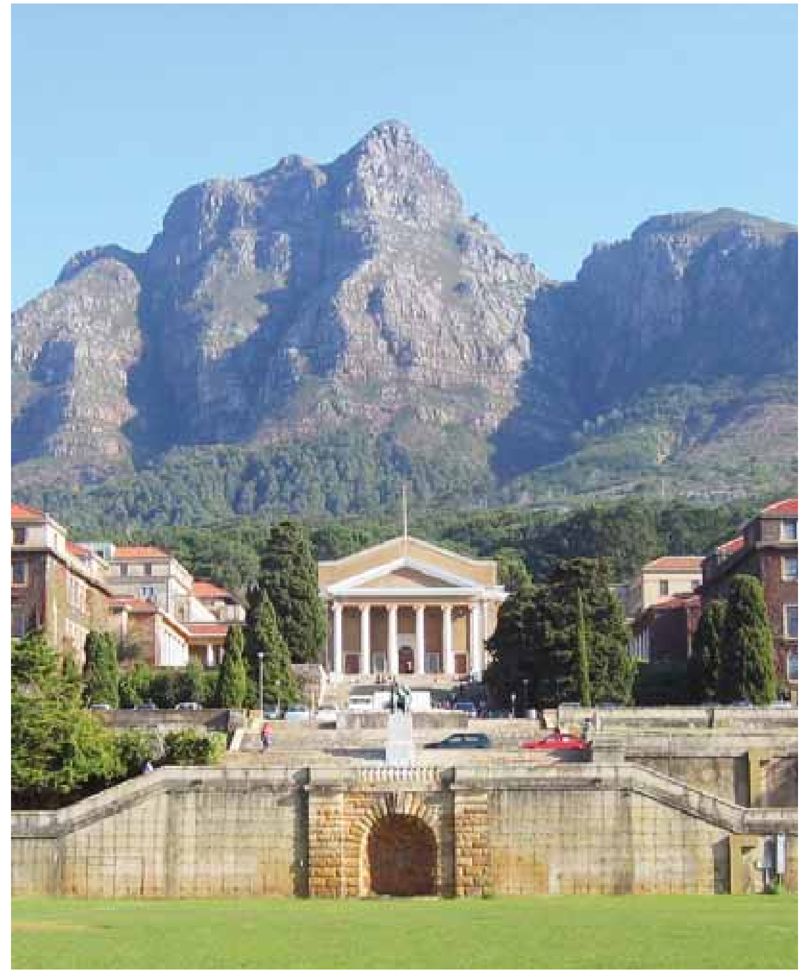
Franzidis, in turn, decided to retire and settle in Australia where his children reside.

"The collaboration between the JKMRC and UCT has been unquestionably one of the highlights of my career, not only because of the enormous value this collaboration contributed to research activities at UCT, but more importantly, because of the incredibly good friendships we developed over time," said Professor Cyril O'Connor, head of department at UCT

"One of our most important colleagues and friends was Emmy Manlapig, who with J-P, played arguably the key roles in ensuring that on the ground the collaboration worked! There are many others who are more than worthy of mention.

"As I recall, some years ago the JKMRC received an award from the Australian government for its development of international collaborations. UCT is proud to know that it contributed in some small way to JKMRC receiving this prestigious and well-deserved award."

The collaboration between the research teams resulted in sharing research staff and postgraduate alike. With the groups closely aligned, many UCT graduates elected to pursue their Master's or PhD research at the JKMRC.



The University of Cape Town campus

The CRC for Optimising Resource Extraction is also known as CRC ORE

THE REMARKABLE DURATION OF P93

After 17 years, Project P93 ended in 1995. It was one of the most successful and influential of all JKMRC research endeavours.

The project transformed blasting practice within the industry and its impact was felt internationally, particularly in Canada, Chile and South Africa.

The gained knowledge formed the basis for other JKMRC research in mine-to-mill projects, caving research and in some of the work of the current day, as being applied by the CRC for Optimising Resource Extraction.

P93 provided the foundation for JKTech software sales and consulting in the mining area. It spawned new instrument developments which are routinely used today.

The themes of the latter period of P93 in a sense mirrored where the project began in 1978 – modelling of explosive performance, modelling excavator performance, modelling and control of environmental aspects of blasting, and the continued development of fragmentation and muck pile models, along with software design tools.

The effects of blast damage to coal and pit walls and underground structures emerged as a major theme over time, but in many aspects there was a fitting sense of the research maintaining its original ethos.

FOREIGN ENVOYS

The rapid expansion of JKMRC's commercialisation arm – JKTech – changed many things. One was the need to use local agents on the ground in various overseas locations including India, Peru, Brazil and South Africa.

All were countries where JKTech sold software and undertook consulting.

These relationships were crucial in the early years, as JKTech negotiated cultural differences, legal issues and variations in local conditions and requirements when working overseas. Many of these local agents became part of the JKTech family, none more so than Mark Richardson in the USA.

Richardson and Rob Morrison had been colleagues within Fluor Engineers and the decision to appoint Richardson as the North American agent was proved many times over the decades.

By 1995, overseas sales accounted for 16 percent of JKTech's income. By the end of the decade, overseas sales were approaching half of the income.

GLOBAL IMPACT OF THE MLA

The first company to purchase the Mineral Liberation Analyser (MLA) was South African mining company Anglo American Platinum in the year 2000.

Anglo American Platinum was so convinced of the value of the MLA that it wanted its own.

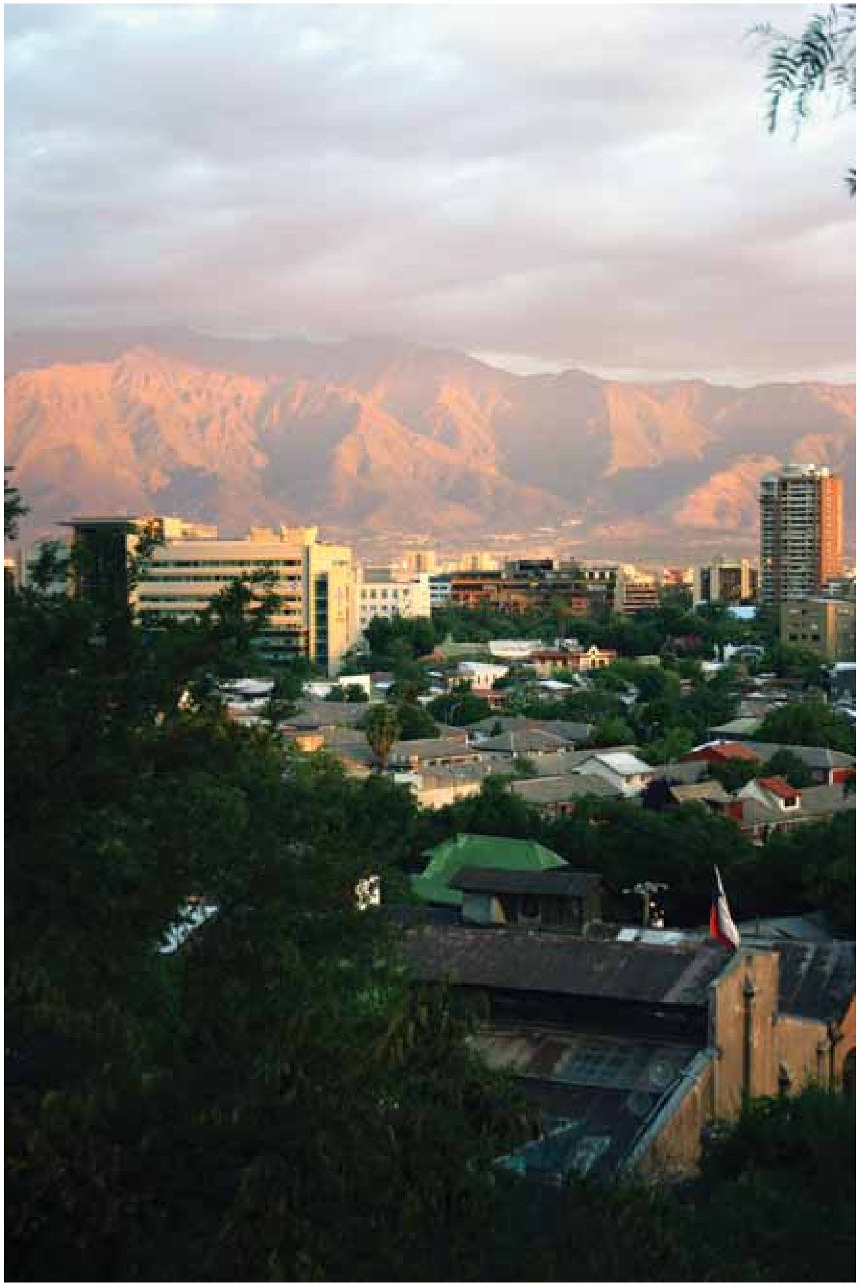
It subsequently became a strategic partner in further development of the technology as well as ultimately having 14 systems, the largest collection of MLA instruments, in Johannesburg.

Until 2005, MLA units were mainly installed at research centres attached to international mining companies such as Rio Tinto, BHP Billiton, WMC Resources, Newmont Mining, Teck Cominco and Inco.

From 2005, MLA units started to be installed at mine sites, starting with Richards Bay Minerals in South Africa and Kennecott Utah Copper Corporation in the USA.

By 2008 the MLA had become the leading automated mineralogy system globally.

The Mineral Liberation Analyser enjoyed widespread popularity in the industry



The Andes provide a backdrop to Santiago, Chile

Ironically, its competitor was Intellection, a company formed by CSIRO to further develop and market CSIRO's QEM*SEM.

Ying Gu remained the leader of the MLA activity, supported by a team of a dozen. One of these was Kurt Moeller.

Moeller had joined the JKMRC as a trainee in the pilot plant in the 1990s. He became associated with the MLA project in its early days and subsequently travelled the world installing systems.

The availability of the MLA had a major effect on the fortunes of JKTech. As the MLA became rapidly recognised as one of the world's most advanced mineral technology tools, the bureau grew into a substantial business known as JKMineralogy.

ANOTHER CHAPTER IN CHILE

Continuing UQ's long and close association with Chilean mining that dated back 40 years, in 2013 JKTech became heavily involved in the development of a Sustainable Minerals Institute (SMI) proposal to establish a Centre of Excellence in Chile.

The centre was established to fundamentally improve the productivity and address environmental consideration in Chilean mining operations.

Known as SMI-ICE-Chile (with ICE standing for International Centre of Excellence), it had the mission statement of "delivering demonstrable benefit to Chilean people and its economy" and "being at the forefront of innovative research and technology transfer to address several of the major challenges and competitive pressures faced by the Chilean Minerals sector".

The proposal, was based on linkages with Chilean universities and the local industry and sought Chilean government funding. It was driven by Chris Moran, director of SMI at that time, Ben Adair and Dan Alexander from JKTech

Note was made that 98 new mining projects had been identified in Chile for the period of 2007-2015, and that increased capacity and innovation were needed.

The proposal was successful, and the SMI Centre of Excellence in Chile was established, led by Professor David Mulligan former Director of the Centre for Mined Land Rehabilitation. SMI-ICE-Chile currently has 20 staff and is currently running nine projects with companies such as BHP Chile, Anglo American Chile and Antofagasta Minerals.

At the time of print, one of the newer projects involving SMI-ICE-Chile was in conjunction with Mitsubishi Corporation subsidiary MC Inversiones Limitada, focused on providing sustainable water supply system planning tools to Chilean industry and society.

LYNCH'S INTERNATIONAL LEGACY

When Alban Lynch's career wound down, he embarked on something he had always enjoyed – travelling the world.

He and wife Barbara spent large parts of the next 15 years or so attached to overseas universities, but always in interesting places, with Chile, Brazil, China, Mexico, Malaysia and Turkey on their travels.

Two of these sojourns, to Mexico and Turkey, were to have lasting impacts on the JKMRC.

In Mexico he became close to local mining companies, which was to have an impact in 2015 with a successful JKMRC study trip and ground-breaking classification research by Juan Jose Frausto Gonzalez, another Ian Morley award-winning PhD student.

His time at Hacettepe University in Ankara rekindled an interest in dry grinding for the local cement industry and he also discovered Hakan Benzer, a staff member in the Mining Department who became a willing disciple to modelling and simulation.

Hacettepe Üniversitesi in Turkey

Just about wherever Lynch went, new students followed his suggestion to undertake postgraduate work at the JKMRC.

The dry grinding expertise at Hacettepe, Turkey resulted in that University becoming a research participant in the ongoing Project P9.

CHAPTER 7

DIVERSITY & EDUCATION LIKE NO OTHER

UNITED NATIONS

Associate Professor Kym Runge recalled that the Julius Kruttschnitt Mineral Research Centre was fondly known as 'The United Nations' by mining companies.

The UN comparison was due to the sustained diversity present in the student and staff populations from the earliest years of its existence.

Certainly, overseas visitors were a feature of life at the JKMRC in its formative days. These individuals were embraced and championed by the centre.

Apart from offering technical expertise, visitors introduced different cultures, an admirable work ethic and helped broaden the outlook of everyone associated with the JKMRC.

More than 280 people have studied at the JKMRC since it opened and a substantial portion of them were born, raised or educated overseas, with many additional graduates mentored abroad later in their careers.

Mark White was a student in the mid-70s and he recalled a collegiate centre where people worked hard and benefited from the influence of those like Toshio Inoue and Yoshi Nakajima from Japan.

During White's time, he recalled tennis becoming a particularly popular pastime.

At various times, other pursuits like cricket, cars and tales of travel adventures also helped bond the staff and students of the centre, no

The JKMRC brought together under one roof a wide cross-section of the global community matter their background. As mentioned earlier, later decades would see the JKMRC social bonds establish the JK Jackals, with touch football, soccer, mining games, and even the 'Oresome Foursome' rowers as favourite team activities.

A strong argument could be made that the most important product or legacy of the JKMRC has been its graduates, who have filtered into the wider world and throughout the industry, leaving a distinct impression.

The willingness of people to welcome, respect, encourage and afford responsibility to those from diverse backgrounds is central to this continuing pipeline.

In many ways the JKMRC was ahead of its time in terms of diversity.

TC Rao came to the JKMRC from India to undertake his PhD, which was completed in 1965 and set him up for a remarkable career.

His legacy is still apparent at mine sites where people remember his impact. He helped blaze a trail for so many others to follow.

In addition to multiculturalism, gender diversity at the JKMRC is strong and today the centre boasts over 45% female representation, with several in leadership positions.

A more recent photo displaying the JK Mineralogy Group

ARE YOU RAO?

As has been mentioned previously in these pages, the earliest undertakings of the P9 Project which gave birth to the Julius Kruttschnitt Mineral Research Centre owed a lot to a student from India – Tadimety Chakrapani Rao.

"I wrote to Professor Frank White at UQ, seeking financial support to conduct my PhD," recalled Rao.

"He replied with the offer of a teaching fellowship and admission into the PhD program of the Department of Mining and Metallurgical Engineering.

“He also provided an airline ticket. I landed at Brisbane Airport around 5pm on a Sunday in 1961 and walked down the stairs, mind blank and exhausted.

“Then a man, fully-dressed in a white shirt and tie, with an impressive moustache, walked towards me and asked ‘Are you Rao?’. That was Professor White.”

Rao spent much of his early time in Australia at the Mount Isa Mines company barracks, often working with Alban Lynch on painstaking measurements in a hot, remote location.

To add further international flavour, Norwegian sailor Chris Madsen was assigned by the company to work alongside Rao on the test rig.

“Rao was a very good experimentalist – as good as I have ever encountered,” Lynch stated.

“In the end, he got a whole mass of extremely good data.”

When in Brisbane, Rao spent most Sundays at the Lynch family home at The Gap.

He and his boss would sit outside and argue over hydrocyclone modelling.

“It’s all very simple now, but it wasn’t back then. It was totally new,” Lynch recalled.

“My wife Barbara would be inside with a stack of children and we would be outside sorting out the cyclone.”

The cyclone model developed by Rao, made circuit simulation possible.

It was an incredible breakthrough, considering how Rao himself remembered the early stages of his arrival.

In 2018 TC Rao was recognised with a special award, naming him the ‘father’ of Indian minerals engineering

Varaha Lakshmi Narasimha_temple in Simhachalam, near to where TC Rao first started his tertiary studies at Andhra University

"I had no knowledge of my PhD topic and who would supervise me, until Professor White assigned me to Alban Lynch," admitted Rao.

"I had never seen a hydrocyclone, let alone such a big plant as the concentrator at Mount Isa Mines.

"Alban and I lived in tin barracks. It was hot and noisy, with large trucks going past all night.

"We are in the mess and washed clothes in a communal washing machine.

"I was blessed to be in the right place at the right time with an exceptional person like Dr Lynch.

"I would do it all again."

In 2016 Rao returned to the fore again, receiving the prestigious UQ Alumnus of the Year award for his stellar career.

Away from his accomplishments with the JKMRC, Rao boasted a remarkable career within India's own University, government and industry sectors.

Some, such as Don McKee, went as far as describing him as the "grand man" of Indian mineral processing.

Like Lynch, Rao was a quietly-spoken man in everyday conversation who would transform into a powerful orator when given the right platform and topic.

DEVELOPING GAMECHANGERS

Naturally, developing great people is made easier by attracting talented prodigies in the field.

Littered throughout these pages are stories of individuals from all corners of the planet who saw the JKMRC as the perfect place to harness their aptitude for minerals research.

"The legacy of JKMRC alumni, continues to attract excellent students and researchers that want to tackle the difficult problems facing the mining industry" said the Sustainable Minerals Institute Director Professor Neville Plint

"The winners of the Ian Morley Prize – which is awarded to the top PhD student at the JKMRC – have gone onto become the 'Who's Who' of the mineral processing world.

"Doing your PhD at the JKMRC really does set you up for a first-rate career.

"It does become a self-fulfilling prophecy in many ways because the best people around want to study there, and the centre gives them the opportunity to develop by doing challenge-led research that addresses difficult problems.

"And the fact our graduates are working with stakeholders from very early on, going out to site, being involved in actual business operations…it allows all the components to come together for them and it's fantastic to see people flourish in such a relatively short space of time."

SNAKE WRANGLER & RECEPTIONIST

A key female figure of the early days was Libby Hill. Hill replaced Joan Richardson (mentioned in *Chapter 1: Pioneering & Daring*) when she left to start a family.

Hill stayed at the centre for 30 years, and remembers that, when Alban Lynch gave dictation, she often filled a whole notebook with shorthand.

Other duties for Hill included staffing reception, arranging coffees and meals for visitors, and acting as a courier between the St Lucia campus and Indooroopilly site.

Juan Frausto Gonzales, winner of the 2017 Ian Morley Prize

Red-bellied black snakes have been known to provide a rare hazard at the JKMRC

Possums also inhabit the Finney's Hill precinct

An unusual, but regular part of her job was to warn people to watch out for black snakes on a path, or arranging for catchers to come and remove snakes that were too much in the way.

One day a carpet snake calmly slithered up the front stairs into the building. Another day a huge snake fell from a girder onto the head of a student walking underneath.

Staff and students sometimes saw snakes eating possums and everybody talked about how fast one mine visitor moved when he climbed down a ladder into the pit and nearly put his foot on to a red belly black snake.

The moral of these stories is that the mine site was still a scrub and lantana infested area, far removed from the landscaped beauty of the St. Lucia campus.

Hill often had to do the little jobs that people thought took no time at all, like cleaning up the kitchen. Lynch would help with that, with assistance from students on rare occasions. Hill complained about the situation and Lynch purchased a dishwasher to alleviate the problem.

"One morning I found all the cork tiles had come off the wall of the kitchen overnight," remembered Hill.

"Soapy water had exploded out of the dishwasher and soaked the tiles off the walls. I went and told Professor Lynch that some idiot had put liquid detergent into the dishwasher instead of powder and there had been an explosion of suds.

"'Oh really?' Alban said, looking worried. So, I knew who had done it."

When Hill departed the JKMRC in 2007, her loss was felt by all who appreciated just how much she took under her remit.

LOVE CELEBRATED

When Emmy Manlapig left the Philippines to join the JKMRC in the 1970s, he had left his girlfriend Lily behind in their homeland.

Dr Alban Lynch lured Manlapig to Australia after receiving a strong recommendation about his abilities.

Clearly a romantic at heart – despite the tyranny of distance and his professional preoccupations – Manlapig chose Valentine's Day of 1976 to visit the General Post Office in Queen Street and make an overseas call to Lily.

He asked for her hand in marriage.

When Lily agreed to his proposal, Manlapig next made a formal visit to Dr Alban Lynch and asked him to become his godfather. In the Philippines, godparents are for weddings, as well as christenings.

Lynch was only too happy to fulfil the role and was said to have played his role handsomely.

Lynch and wife Barbara flew to the Philippines for the splendid wedding, which Lynch forever after remembered by the wedded couple joyously throwing pigeons into the air to mark their vows.

When Lily joined Manlapig in Brisbane, the Lynch family threw a massive welcoming party and invited the whole team from the JKMRC, staff and students included.

"In those days at the centre we all relied on each other," said Manlapig.

"Lily and I often visited Alban and Barbara at their house and I felt I could ask him anything.

"It was the same with my colleagues. We proof-read each other's theses and we were great friends."

A NIGERIAN WEDDING

Mirroring the nuptials of Manlapig was another subsequent joyous occasion, when Nigerian Sylvester Awachie married his fiancée Mabel in 1981.

Some of the most memorable events in the history of JKMRC were weddings

Brisbane's Queen Street Mall in approximately 1980

Brisbane's central business district as it looked in the late 1970s and early 1980s

Awachie had first arrived in Australia in 1978 and spent three years at the JKMRC before bringing Mabel to live full-time in Brisbane.

"If he returned to Nigeria for a wedding, he confessed, he would be liable for huge costs, as all the residents of their two villages would have to be invited and fed," recalled Don McKee.

"Alban Lynch rose to the challenge, assuring the young man that he and wife Barbara would organise the wedding and the reception."

The wedding became a major and memorable event in JKMRC's history.

A colourful ceremony was held at a small chapel in Ashgrove, with the bride escorted down the aisle by an African friend in traditional tribal robes. Members of JKMRC helped organise other aspects of the wedding, including readings from scripture.

Guests from more than 17 countries were in attendance – many Sylvester's friends from International House at UQ.

Female staff and students from JKMRC helped Mabel with her wedding gown, baked and iced the wedding cake, and prepared a sea of flowers at Lynch's home at The Gap.

The Lynch's family abode was transformed into a colourful, festive space for the reception.

The newly-weds would go on to have a daughter, Nancy, who grew up as an Australian citizen.

For Lynch the occasion was further proof of what was really behind the success of the centre he had founded – the energy and empathy of its people.

HAVING A BLAST

One of the most diverse groups in the history of the JKMRC was the blasting research team.

Cameron McKenzie built his team from scratch and, it proved to be an eclectic mix.

It featured Nihal Liyanaarachichi of Sri Lanka as the first student, Zimbabwean mining engineering graduate Gideon Chitombo (who arrived via the USA), and Jeff Dawes, who relocated across the country from Western Australia.

There were others like Eddie LeJuge and Alex Kavetsky who had been raised in Australia, but with tell-tale surnames to indicate their heritages.

Elsewhere in the blasting team, there was agricultural scientist Shirley Williams, electrical engineer Steve Hickey, electronics technician Jim Shields, and Tom Kleine who joined from the mineral processing team.

The group was remembered for being a particularly tight-knit and diligent assembly of individuals.

GIDEON'S GREAT MEMORIES

Gideon Chitombo recalls how as a PhD student he was, thrown into the deep end on mining sites in a tried-and-true JKMRC tradition, somewhat akin to a baptism of fire.

"JKMRC students weren't seen as people doing PhDs," Chitombo recalled.

"We'd be given a problem or a job and were expected to work it out. We thrived on the challenge. It was the great thing about being a PhD student then."

"We took outrageous risks. We'd pluck someone out of the pool and say: 'Tackle this'.

"There was a notion that you didn't have to know a lot about anything before you tackled it. And it usually worked out. There was a balance to the work.

Professor Gideon Chitombo holds an audience in his early career years

Ernesto-Villaescusa

Shinichi Akutagawa front, fourth from left, leads an International Workshop for Young Civil Engineers

"We loved going to the mines. The question was always: What's new? As a student that was a fantastic experience. We knew we were working at this centre of excellence, we weren't a consulting group. We knew what we were talking about."

FANTASTIC FIFTEEN

The spirit of the previous decades was maintained throughout the 1990s, a feat made easier by a large and vibrant student body which came from more than a dozen nations.

In 1998, there were students from 15 countries who had brought their unique skills to the relatively small Julius Kruttschnitt Mineral Research Centre at the same time.

Nearly the entire globe was covered, with students from North and South America, Europe, Asia, Africa and Papua New Guinea enrolled.

The student group initiated International Night celebration, an event which thereafter became an institution. International Night celebrated the composition of the students with an array of food, drink and cultural performances.

Kym Runge, who graduated from the department as a minerals processing engineer in 1991, described the decade as a truly vibrant time for students.

"Alban and others had talked up the JKMRC all over Australia and the world," said Runge.

"So a whole generation of students wanted to come."

Professor Ted Brown's influence on mining activities was also well established as the decade began.

His supervision of two students, Ernesto Villaescusa (Mexico) and Shinichi Akutagawa (Japan), from the late 80s was the start of a long period during which he guided the fortunes of many JKMRC students.

Fittingly, when the JKMRC celebrated its 100th student to receive a PhD many years later in 2002, it was Chilean Marco Vera who notched the important honour.

A GEOLOGIST TAKES THE HELM

Alice Clark originally came to be part of the Julius Kruttschnitt Mineral Research Centre because of a move to strengthen the organisation's geometallurgical research capabilities.

Clark had been the Chief Geologist for Mount Isa Mines, Deputy Chairman of the Join Ore Reserves Committee and the first female president of the Australasian Institute of Mining and Metallurgy, coming from an accomplished background with roles in geology, mining engineering and management.

Clark started in 2012 for a 6 month period and then returned in 20152016 recruited as Director of the Sustainable Mining institute's Production Centres (JKMRC and the W.H. Bryan Mining and Geology Research Centre (BRC).

After a period of high staff turnover she brought stability to the centre setting strategy and a clear direction while making tough decisions on funding priorities, staffing and maintaining centre morale in the face of ongoing challenges of the time.

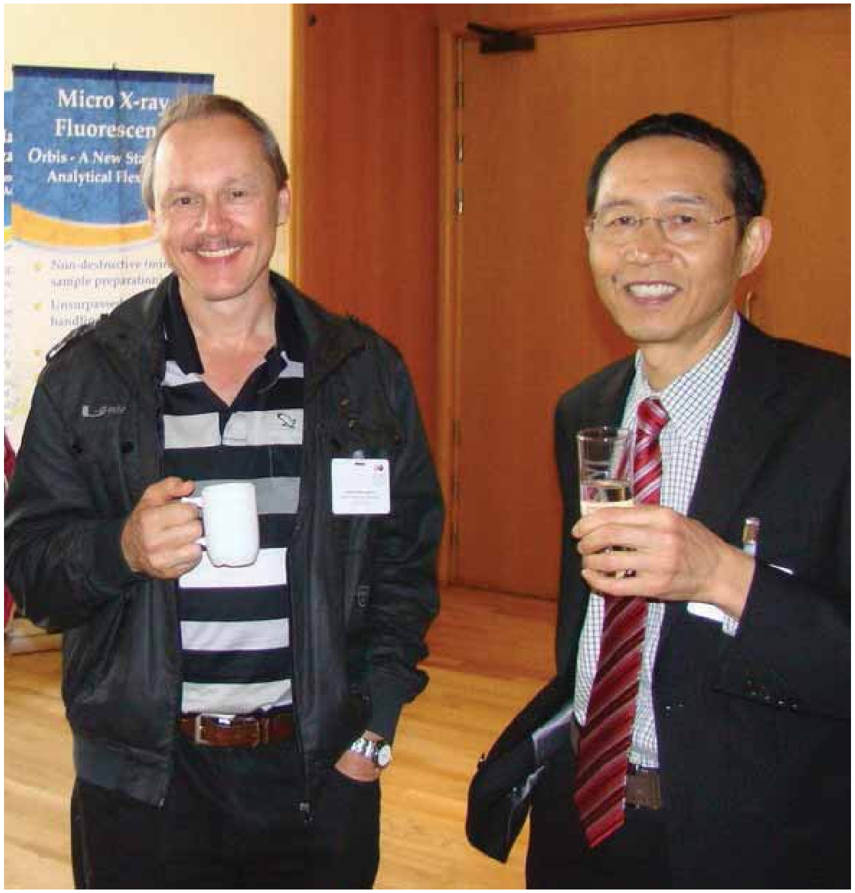
The centre relied on industry funding through collaborative research however, the mechanisms of acquiring funding had changed radically from the early days of the JKMRC.

Clark identified a new set of leaders from within the Centre who she coached in how to approach industry with solutions to the complex problems that challenged today's mines.

She connected the new team with her industry contacts resulting in research initiatives linking energy savings, reduced water usage and minimising tailings.

Professor Alice Clark

Internally, she moved the BRC onto the Indooroopilly site. Now co-located with the JKMRC she worked with key researchers covering the mining value chain from geology, mining engineering and mineral processing to build a cross-disciplined team strategically aligned to solve the next set of mining challenges.



Dr Ying Gu is remembered for a tireless and spectacular contribution

DR YING GU

Born in China's Jiangxi province to two geologists, Ying Gu was always seemingly destined for a career in the field.

Although his tertiary education was delayed by the Chinese Cultural Revolution, he achieved first class honours in geochemistry at Nanjing University, followed by a masters degree.

Deciding to migrate to Australia, Ying then completed a PhD in earth sciences, a graduate diploma in computer studies, then went to work in mining in Western Australia for two years.

He moved to Brisbane originally to work with CSIRO, contributing to the ground-breaking QEMSCAN, a scanning electron microscope which took much of the time, effort and guesswork out of identifying the mineral composition of process streams in processing plants.

In the 1990s the Julius Kruttschnitt Mineral Resource Centre felt it needed access to an automated in-house mineral measurement system and employed Ying from 1996.

Ying was given a brief to develop a Mineral Liberation Analyser (MLA), with centre bosses knowing he had two key areas where he possessed outstanding expertise – extensive knowledge of minerals and highly-developed software skills.

With an unflinching focus, Ying doggedly saw the MLA through to completion, with the commercial version released in 2001, leading to sales all over the world.

"Like all great innovators, Ying had the passion to want to change the world," said colleague Tim Napier-Munn.

"He had the vision for what he wanted to change, the technical skills to do it, and the work ethic and resilience need to overcome the difficulties.

"Ying made a seminal contribution to the automated quantitative analysis of minerals, loved his customers and wanted them to be successful in using his technology. His customers often became his friends.

"More than that, he was a devoted family man; kind, humble and easy to get on with."

In all, Ying spent nearly 20 years with JKMRC and JKTech.

Sadly, he passed away in 2019 at the relatively young age of 62, following a three-year battle with lung cancer.

LET'S BE FRANK

Everybody at the JKMRC knows him as Frank Shi, but the widely-influential professor was actually born in China with the name Fengnian.

Shi came to the JKMRC in 1988 as a visiting academic and was awarded a PhD from The University of Queensland in 1995. His impact since has been nothing short of amazing.

Working in both conventional mechanical comminution and high-voltage electrical comminution, and he is one of the major inventors of four patents.

Shi has published more than 100 papers, boasting an average of more than 10 papers per year for a large period of his career.

His work has played a major role in the JK Rotary Breakage Tester, the JK Fine-particle Breakage Characteriser, and the JK Coke Strength Index, as well as developing mathematical models used in impact hammer mill models, verticle spindle mill models, and energy-based ball mill model.

Professor Frank Shi

The tireless worker was joint winner of the prestigious global award, the CEEC Medal, in 2017, awarded for outstanding advances in eco-efficient comminution and mineral processing.

Associate Professor Kym Runge comes from a family background steeped in pioneering history

DECEPTIVE ON PAPER

The name Kym Runge on paper points to two facts. Firstly, she is female. Secondly, her family name gives away origins near the current German-Polish border.

If anything however, Runge's name masks a lengthy and fascinating family involvement in the Australian domestic mining scene.

In 1927 her great-grandfather, WH Runge, took over the most productive mine in Gympie's rich gold fields. It had produced 608,279 ounces of gold from more than 1.5 million tonnes of ore between 1867 and 1923.

Kym's grandfather, Irvine 'Irv' Runge, continued the family tradition, not only involved in mining and mineral recovery, but heavily involved in preserving mining artefacts for historical purposes.

Upon his death in 2015, 'Irv' Runge was described by *The Gympie Times* newspaper as "one of the last links to private mining in this region".

Several members of the wider Runge family have since become involved in the industry, no doubt invigorated by the quite spectacular machinery and memories attached to their youth.

"Kym's a pretty special individual," said Professor Alice Clark.

"One of her defining attributes is that she has achieved so much in her life without seeming to put anybody offside. It's really hard to do good research, be in a University environment, oversee others and not ruffle feathers.

"She's very unassuming, but once she opens her mouth, the confidence she exudes is amazing. She knows the field inside-out. She knows what she is doing.

"Kym has the ability to bring together researchers from what might appear disparate and conflicting areas and say: 'If I can make this work, there's something big at the end of this'.

"Her work around the birth of coarse particle flotation shows her capacity for original thought.

"Kym has a distinctive leadership style. People were always lined up outside her door to seek her advice.

"When we were looking for someone to step into Dee Bradshaw's enormous shoes Rob Morrison reflected that Kym Runge was 'just brilliant'. High praise indeed."

Runge was the 1988 winner of the Ian Morley Prize for the best PhD at the JKMRC, helped develop JKSimFloat, consulted on flotation before being employed by the JKMRC and has won numerous industry, state and national awards, including the 2003 Smart State Smart Women award.

MOHSEN THE MACHINE

Like several overseas-born students, Mohsen Yahyaei became enraptured with the idea of working at the JKMRC through reading the centre's monographs and investigating its reputation.

"In Iran it was not easy to access academic books and other materials, but as I started my formal training, I started to know about the JKMRC and the people working there," said Yahyaei, now Group Leader on Advanced Process Prediction and Control at the centre.

"I thought 'I have to get to this place'.

"And I always wanted to be a person actually not just using the outputs from JKMRC, but somebody who actually contributed to it."

Although a series of hurdles prevented Yahyaei from leaving for Australia, he not only eventually made his dream come true, but he

Associate Professor Mohsen Yahyaei on-site at the JKMRC

Marcin Ziemski

also performed the remarkable feat of establishing a similar research centre in Iran.

“At the moment we’ve got 16 Masters students in Iran actually embedded into innovative industries in copper and iron ore for example,” he said.

Yahyaei’s work ethic has seen him nicknamed ‘The Machine’, but he explained his relentless schedule was by choice, rather than by obligation.

“It might look like I’m working 24-7, but this job is something I actually enjoy,” Yahyaei said.

“To me, it’s a hobby. I’m always on vacation…doing something that I like.

“There are a few things that are important. Firstly, I’m working in a place where I have an opportunity to develop my idea. I can build my concept, develop it and then push it to the point where it can be implemented.

“I don’t see a lot of similar centres where this is possible.

“The other thing is the culture of the JKMRC and you have different perspectives, which I believe is a real strength.

“Now it’s in the Sustainable Minerals Institute, we interact with other groups that are not focussed on processing and they provide a new angle.

“It’s been an eye-opener for me.”

THE RETURNED

Marcin Ziemski has gone a few rounds, hopping on and off the JKMRC ride. A mechatronic engineer with skills in IT, he came to UQ for a job interview but stayed for a PhD at the JKMRC. He joined the relatively new Mineral Sands group in the late 1990’s. He has since spent much time lending his adaptable skills to JKMRC flotation research, JKTech consulting, before leaving UQ and entering the corporate sector.

Marcin spent over 10 years using his expertise to provide consulting and technology transfer to both the mining and energy industry. But he could not stay away for long.

"Once you have worked or studied at the JKMRC, you are part of the JKMRC family and it is part of you. You always maintain a keen interest in JKMRC research and support it directly if you can. The temptation is always there to solve the industry's wicked problems. That's what brought me back after so many years in the corporate sector; the desire to develop and test new ideas, solutions, technologies in the 'JK' environment", says Marcin.

Upon his return, Marcin established the Mine Energy Transformation and Integration (METI) group. He also used his corporate skills in leading the JKRMC as acting director for fifteen months between late 2018 and early 2020.

Marcin's role is now as Commercial Services Lead. The role spans across the SMI, encompassing both JKMRC and JKTech.

OPENING DAWES

A great example of the international opportunities created by the JKMRC occurred in 2015 when Dr Jeff Dawes was recognized as The University of Queensland International Alumnus of the year.

After completing his PhD Dawes had been the centres's first resident person in Chile back in 1986.

He rose to head Komatsu in South America and is now based in Milwaukee as President and CEO of Komatsu Mining Corporation.

Jeff Dawes has been an esteemed almnus of the JKMRC in modern times

The late Professsor Dee Bradshaw

REMEMBERING DEE

Originally, Zimbabwean Dee Bradshaw was destined to spend just four months in Brisbane working with the Sustainable Minerals Institute in 2008

Bradshaw loved her time so much, she stayed for seven years, filling a variety of senior roles with the JKMRC and SMI.

She had obtained her PhD in Chemical Engineering from South Africa's University of Cape Town in 1997, after first obtaining a Bachelor of Science in 1981 and then raising a family.

Bradshaw became internationally renowned as an expert in the field of flotation, yet this is only part of her legacy.

Always passionate about inspiring and nurturing countless young academics, she was universally admired and was considered guiding light for the industry and a true personal mentor by many, including Kym Runge.

Devastatingly, her life was cut short by cancer, just months before her 60^{th} birthday, and shortly after publishing her book *Green Mining: Beyond the Myth*.

"Everyone loved her. At her funeral, someone got up and said 'She made me feel like I was the most special person in the world'. That's how she made me feel, and I now know that's how she made everyone feel," said Runge.

"She was positive about everyone and believed in the best in everyone, and because of that everyone wanted to collaborate and pull together.

"She was such a beautiful person and I feel very privileged to have had my time with her for five years as my boss."

Colleague Malcolm Powell described Bradshaw as 'a wonderful person' and recalled how she adored the forest adjacent to the JKMRC.

He said working alongside her was one of his highlights.

"It takes a lot of effort to build relationships with groups and people, but Dee Bradshaw was deeply understanding of that. Anybody who saw the hours per week she spent on building confidence within people to work together would understand that.

"It's something that doesn't come naturally for many scientists, but for her it did."

Bradshaw once said that a big reason for her wanting to stay in Australia was because former JKMRC Director Don McKee had pushed her out of her comfort zone, asking her to lead the EnviroGem project, rather than simply stay in a familiar chemical engineering role.

McKee praised Bradshaw for "her engaging personality, ability to get different people to work together, and a passion to develop young people".

The UQ Dee Bradshaw Travel Scholarship, which helps higher degree students in the minerals sector with international experiences, is a fitting philanthropic program established in her name.

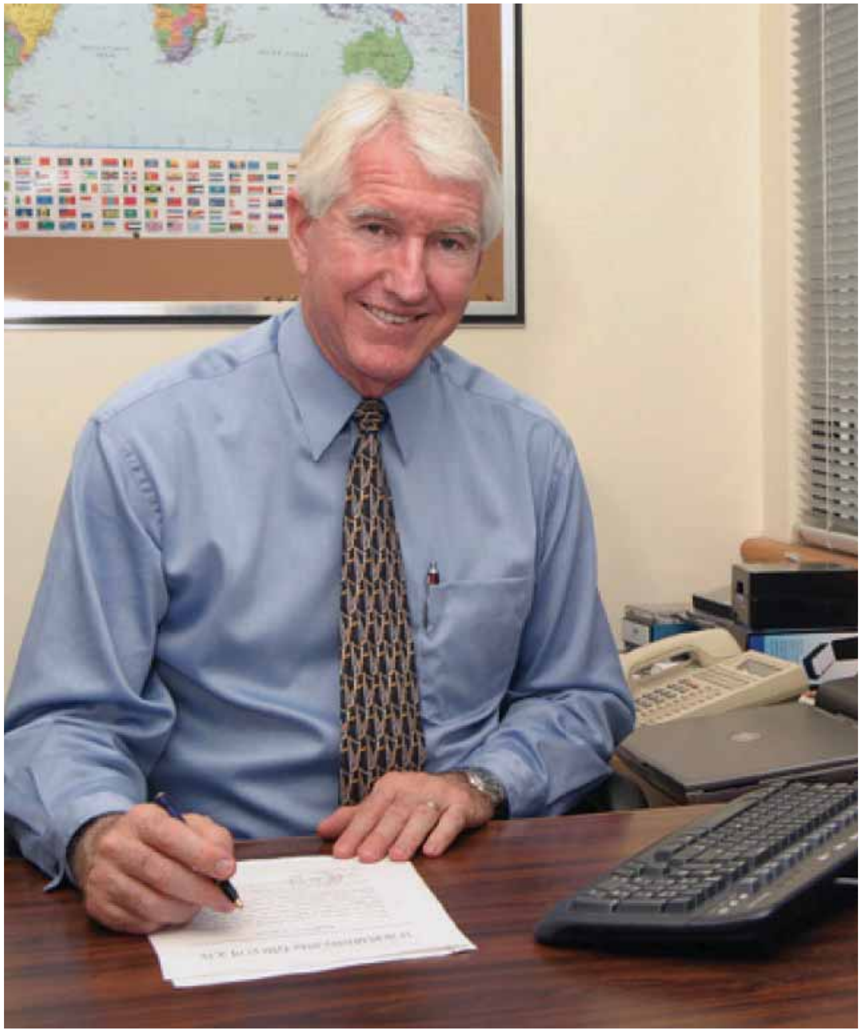
A QUARTER OF A CENTURY'S SERVICE

After 25 years of service, the retirement of Jill Mann in 2012 was considered a landmark occasion.

It could be contended that Mann knew more than anybody about what took place at the Julius Kruttschnitt Mineral Research Centre during her tenure.

She served as personal assistant to five directors – Don McKee, Tim Napier-Munn, Rob Morrison, Ben Adair and Geoff Gault.

Dedicated to a fault and fiercely loyal to her directors, Jill provided much of the glue which kept the centre together through thick and thin. With each succeeding director, her role expanded as she took on greater responsibilities.



Dr Geoff Gault was one of the directors whom Jill Mann served alongside

Mick Kilmartin, Eric Muhling and SMI Director Neville Plint

She was considered a very astute judge of character, and was one of the handful of administrative staff to whom centre people, and particularly students, confided.

Like everyone, Mann had her idiosyncrasies and one was the locked cupboard, which contained quality chinaware to be used when important people visited. Mann held the key to the cupboard safely in her keep.

A lasting characteristic of Mann was her invaluable role in bringing matters, both big and small, to the attention of the directors at crucial times.

STALWARTS' LIST

No list of JKMRC stalwarts would be complete without acknowledging those who have provided the support required to achieve research success, always providing smiling service to the JKMRC for many years, helpful to any who crossed their path.

Bob Marshall and Mick Kilmartin in the workshop worked tirelessly to transform researcher's ideas from the paper into reality. Jon Worth was a fixture in the pilot plant until his retirement in 2016. Eric Muhling was responsible for maintenance of the mine and always keen for a chat. Ray Phillips and Mike Corrie, prior to centralisation, were the ones on hand to fix those annoying computer problems. Karen Holtham, in the library, painstakingly maintained and looked after the JKMRC thesis and book collections.

Back in 2005, Sherrin Brundle joined as the receptionist before becoming responsible for travel. For some years her formal role has been facilities co-ordinator. The reality is much more. She is the person who keeps the place running, following in the long tradition of Joan Richardson, Libby Hill and Jill Mann.

CHAPTER 8

TOWARDS A SUSTAINABLE FUTURE

TOWARDS SUSTAINABLE FUTURE TECHNOLOGIES

As JKMRC passes its 50 year anniversary, it is now led by a young and enthusiastic team, mentored by the current Director, Professor Rick Valenta. It has been structured into three research groups that are heading the centre into exciting new directions.

The Advanced Process Prediction and Control (APPCo) research group is led by Associate Professor Mohsen Yahyaei. It consists of multidisciplinary researchers with comminution, classification, process control, and data analytics expertise. It aims to leverage existing plant operating data together with emerging techniques to provide tools for real-time process control and optimisation. The group's vision is to develop better techniques for generating information from online measurements and existing data that feeds into dynamic process models which are developed for process control. It is also to use advanced data analytics, improved instrumentation and soft sensors to enable real time prediction and informed decision making.

Separation is led by Associate Professor Kym Runge. The group looks at new technologies that have the potential to transform the concentrator of the future. Technologies such as high voltage pulse comminution, coarse and fine particle flotation, microwaves and novel classifiers are being explored, looking to maximise resource utilisation and minimise environmental impact. Flotation chemistry is a key research area, with a focus on novel and traditional reagent chemistries and the exploitation of advanced surface analysis. Advanced computational and particle tracking techniques are tools being used

Using the rotary breakage tester on-site at the JKMRC

While sport is an important part of mining communities, it's not the be-all and end-all says Alice Clark, Photo - Robert Burgin

to better understand and optimise a range of technologies. The separation group aims to make step change for industry by looking at these new and unconventional solutions.

The third program in the centre is that headed by Associate Professor Marcin Ziemski - a Mine Energy Transformation and Integration program. Research of this group aims to enable transformational change in how the mining industry obtains and consumes energy, and to integrate activities across the mining value chain business cycle. The Program focuses on leveraging SMI's existing mining and processing operational know-how to identify strategic energy and cross-disciplinary initiatives for improved operational, environmental and social performance.

MORE THAN SPONSORING SPORTS TEAMS

Professor Alice Clark said that learning how to deal with public sentiment around mineral resource extraction is still a work in progress.

"Social and environmental impacts are absolutely the number one challenges for mining companies as compared to a few decades ago," Clark said.

"Companies recognise this and most have moved beyond buying netball uniforms and constructing cricket fields to try and win favour.

"People talk about mining and society like they are two different things. They are not. Mining companies and their employees, shareholders, families that make a living working in the sector and communities that support the industry are part of society too. The very survival of humanity depends on the supply of minerals and energy. Impacts to climate change, biodiversity are followed by societal response which in turn drives the need for innovation and solutions.

"The challenge for the JKMRC is to develop solutions to the objective of producing the minerals that the world needs while using less energy, water and making less waste.

Clark believes the answer will lie in taking a cross-disciplinary approach to orebody delineation and processing systems that inherently de-toxify mining wastes so that tailings can be used for other things.

She also believes work needs to be done in looking carefully at which minerals are necessary for a sustainable future, and designing everything for re-use.

“The reasons for societal outrage where mining negatively impacts the environment and communities are deeply complex. Some of these issues technology will fix, while others are far more difficult to address.” Clark said.

“Researchers at the SMI want to be involved in research that helps provide minerals needed for a sustainable future – which isn’t all of the currently mined minerals by the way – while simultaneously considering safety, governance, leadership, social responsibility and environmental impacts.

POTENTIAL FOR CHANGE

While reluctance will almost certainly be found every step of the way towards more ecologically acceptable methods of mineral extraction, JKMRC Director Rick Valenta said it is not a reason to diminish ambitions for the industry.

“The potential to transform everything is in front of us,” said Valenta.

“We have to get our heads around thinking you don’t need to build an enormous complex, you don’t need to have 240-tonne trucks hauling loads across the landscape, you don’t need to have a massive tailings dam.

“These are all the things that people dislike about mining.

“It’s a shift from the mentality that looks at a project and asks ‘How do I ramp up to the highest possible production on the fastest time possible?’ where you see anything else as a waste of time.

Professor Rick Valenta

Mount Owen Mine rehabilitation in the Hunter Valley, Photo - NSW Government

Mount Thorley Mine rehabilitation in the Hunter Valley, Photo - Rio Tinto

"It's more closely aligning what these enterprises see as a 'destruction of value' with the implications for the surrounding environment.

"With a really integrated approach we can revolutionise mining… which is something we *have* to do, not something that should be seen as a choice.

"What we're missing is the millions of dollars in research funding required to solve all the problems, but we're getting there step by step".

FINDING INSPIRATION IN REGENERATION

Although Alice Clark is circumspect about how rapidly things will advance before 2050 – "I think we'll still have holes in the ground and waste piles at that stage" – she does draw inspiration from projects already underway.

"I'd like to think waste piles and landforms created by the effects of mining will be re-engineered to sustainable natural systems that while they won't look the same as they did before they will function naturally and support biodiversity," she said.

"One project I enjoy reading about at the moment is the reengineering of the Hunter River in New South Wales and how the rebuilt 'natural' systems are now sustainable and able to evolve through climatic cycles.

"This needs to be the new status quo. We must move away from sticking a cap on the waste piles and leaving it for 1000 years to allow the earth to heal. We need to re-engineer post mining landscapes to become natural systems. You shouldn't be able to tell a mine was there when it's finished.

"That means planning and working out what the final 'natural' sustainable system should look like before mining commences.

"Then, as the operation progress through the stages of mining, including future expansions to eventually winding down, you're mindful every step of the way about what the impact on the resultant natural system will be.

"I think that's a realistic image of what mining in developed nations in 2050 will look like."

When Professor Clark was elected as a Fellow of the Australian Academy of Technology and Engineering (ATSE) in late 2020, she called on the industry to be "forward-thinking and bold".

FIGHTING FOR SUSTAINABILITY FROM WITHIN

As is the case in any industry where you want to see change, you have to make a decision: Do you try and implement change by protesting and abstaining from the industry, or, do you try and bring about meaningful reforms from within?

Professor Malcolm Powell described comminution – effectively breaking rocks – as "the negative part of the negative side of the industry".

So, when he came on-board as founding director of the Anglo American Centre for Sustainable Comminution, he had to change ways of thinking to ensure the name was not a paradox.

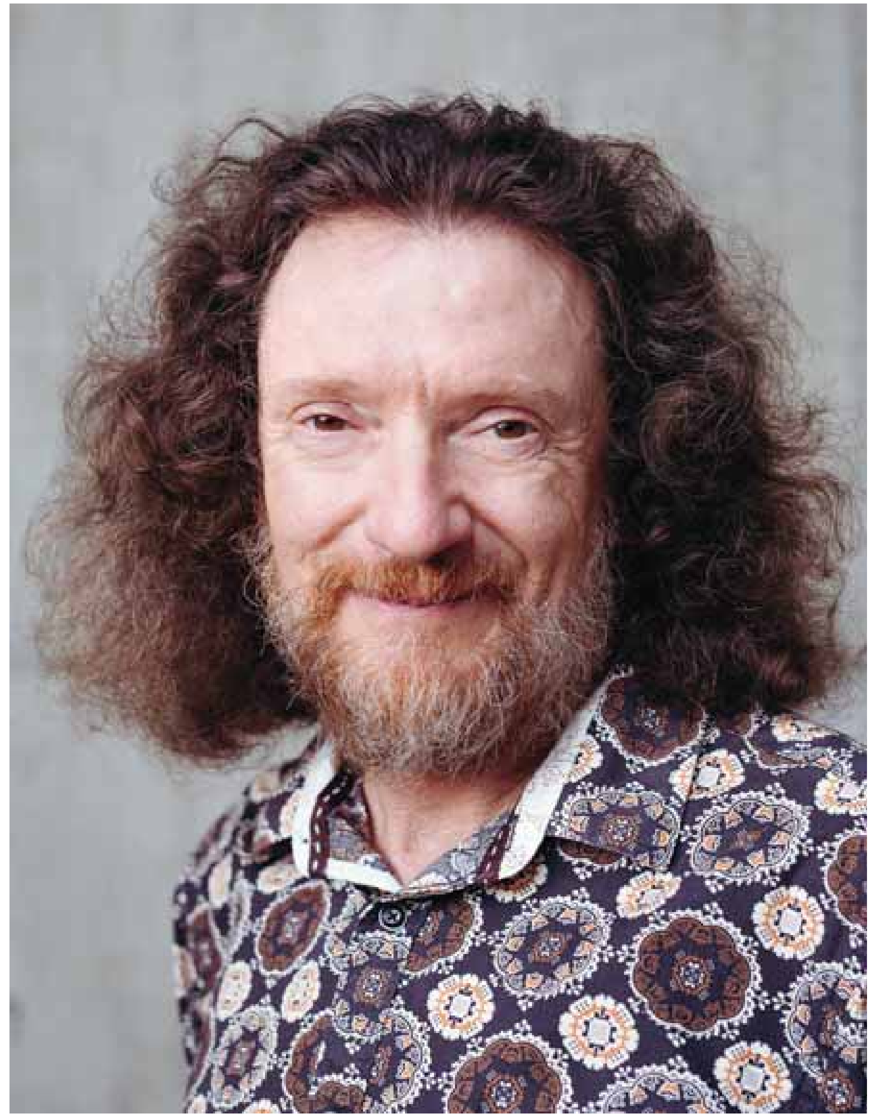
"I was employed under funding for the CSRP (Centre for Sustainable Resource Processing), so clearly sustainability was a fundamental, necessary part of the role," said Powell.

"But I was also from the part of the industry – comminution – which uses the most energy. It's viewed as a one-way journey where you dig big holes in the ground, break rocks and leave waste behind.

"You face pushback from the community that mining is not sustainable, purely by definition.

"So, I had to establish the significance and opportunities for sustainability in this area.

"We looked at how we could make the process as efficient as possible.



Professor Malcolm Powell

Flatbed trailer with mining equipment being transported on the back

Oversized load being carried through a remote Australian region

"The positive perspective for me is that whatever change I can make to encourage efficiency, it's going to make a significant, tangible difference to the environment, because comminution is so demanding of energy.

"It has fundamentally changed how I look at the process. I'm really proactive and positive about the difference we can make.

"It's not lip service for us to say we'll use less energy. Actually, we're some of the people who can help make the biggest transformation to the ways mine sites use energy."

Powell said that the blunt force and repeated overgrinding of many comminution facilities was actually leading to more problems than it solved, such as producing slimes.

He also noted that by re-grinding in batches, some minerals were exposed to 400% extra energy and time expenditure, where 10% more grinding could have been sufficient to liberate some particles.

GREATER EMPHASIS ON COMMUNITY

How should a mine be introduced to a community?

And what should be its social footprint, before, during and after the mine is operational?

Malcolm Powell has championed the concept of a gradual introduction of mining operations, particularly to small, rural settlements where mines can often dominate the landscape, the local economy and the inhabitants' self-identity.

He argued that the model of transporting all equipment at once to the location, completely transforming a region in the blink of an eye, then packing up and leaving just as quick, was by no means necessary or the most beneficial.

In particular, he favours the concept of building local capacity, empowering local people to have a share in the knowledge and financial returns, and preparing them for when the main mine is no longer needed.

"My involvement with the Sustainable Minerals Institute really drove that concept of a deep interaction with the community home for me," said Powell.

"This idea that mining companies dig out the ore, do it in a premeditated, inflexible way, then leave all these problems behind when they exit…that really worried me.

"We must address and minimise the problems.

"Say you change the approach, by coming in with a small company that helps build smaller community companies with a small processing plant that actually mines the stuff that a larger mine could never do economically.

"From that, you start generating income while you bring in the bigger equipment for the main mine site, and you're training people and there is a direct local return.

"Then think about how the evolution of your minesite will affect the local environment. Do you really need to plough that huge road through the middle of communities because you need to get all the big equipment in?

"If you change your equipment, maybe a smaller, less impactful road will be needed, and in turn that piece of equipment will only require smaller complimentary equipment or parts.

"If all your milling equipment can be pulled apart and put into 40-foot containers, then it goes on a standard-sized truck. You're starting to think all the way through the process.

"Towards the end of a mine's life cycle, perhaps the correct way is not to shut down everything and declare it economically unviable.

"Leave the site for a smaller operation and perhaps gift them equipment for 40 years or so, to encourage continuity in the community.

A satellite view of Berkeley Pit and Yankee Doodle tailings pond in Montana, Photo - NASA

Dr Liza Forbes

"I just hate to see a resource not fully used, where there are things valuable to a local community but they are made too inaccessible."

REVERSING THINKING ON SATELLITE PITS

Another concept which has floated around in the head of Malcolm Powell is whether there is another order to constructing pits.

Typically, a main pit is dug first, then smaller satellite pits afterwards.

"But what if you dug those smaller pits first and they're the community pits?" said Powell.

"Then when you've finished that satellite resource, it becomes the best tailings dam you can ever get because it won't collapse.

"Okay, yes you've got to be wary of arsenic and other undesirable elements, but you could develop different process routes where one ends up in a clay base, for example.

"Actually, maybe you could discover a way to treat it and utilise it."

TAKING THE WET OUT OF TAILINGS

An expert in mineral flotation, Dr Liza Forbes joined the Sustainable Minerals Institute's Julius Kruttschnitt Mineral Research Centre in 2018, and has since been integral to the Separation Program's effort to make mineral processing smarter.

"In 2018 I was contacted by Kim Runge from the JKMRC, whom I have known for many years and have worked with previously," Forbes said.

"She asked me to help out with setting up the Collaborative Consortium for Coarse Particle Processing Research (CPR), while I was between jobs."

Kym Runge had realised Coarse Particle Processing was a potential game-changer in mineral processing, and could lead to less use of precious water and an enhanced ability to store tailings in a dry stack instead of a wet pond. This could make mining operations safer, more sustainable, and more socially acceptable.

"We spent six months working on that together while I was still based in Melbourne and during that period I decided to move up to Brisbane and come work at the JKMRC on a permanent basis," said Forbes.

Kym Runge maintains that the project came about in a very traditional JKMRC manner. "The feedback I was getting from industry was 'we're not interested in models, we're not interested in a half percent change anymore'. So I really got the feedback and the feeling that we needed to be looking at things that were going to make step changes. We needed to solve the problems that are stopping us developing our mines."

Liza and Kym Runge are technical directors for the CPR Project.

The project has seven industry sponsors and will run for an initial five years.

HOME IS WHERE THE HEART IS

The JKMRC is set amid an array of flora and fauna. Generations of students, researchers and staff have perfected their craft in an environment featuring owls, possums, brush turkeys, carpet snakes, echidnas and water dragons, to name but a few of the creatures regularly found at the Indooroopilly site.

Being positioned in what could be termed an idyllic setting – a sort of nature refuge in modern suburbia – has emphasised to everyone at JKMRC that there is a wider world to consider.

While classes and texts speak of mineral extraction in dry and matter-of-fact terms, there is commonly a responsibility to the environment that isas front-of-mind for students and staff.

While the core nature of mining's activities result in disruption to the ecosystem, numerous programs and ways of thinking have been adopted to try and minimise the impact along the way.

Water dragons can be frequently seen around the JKMRC precinct

CHAPTER 9

LEGACY & VISION

LEGACY IN DOLLARS

Putting a monetary figure on the work of the JKMRC is difficult.

Perhaps the closest anybody has come was when the centre's commercialisation arm, JKTech, placed a value on the savings created by their software.

The valuation was in excess of $2 billion in savings brought about by efficiencies over a 10-year period.

But clearly that 10-year period forms only a fraction of the existence of the JKMRC.

Software is also only one branch of the knowledge the centre has generated, albeit a significant one, with more than 20 software products now generated by the Centre.

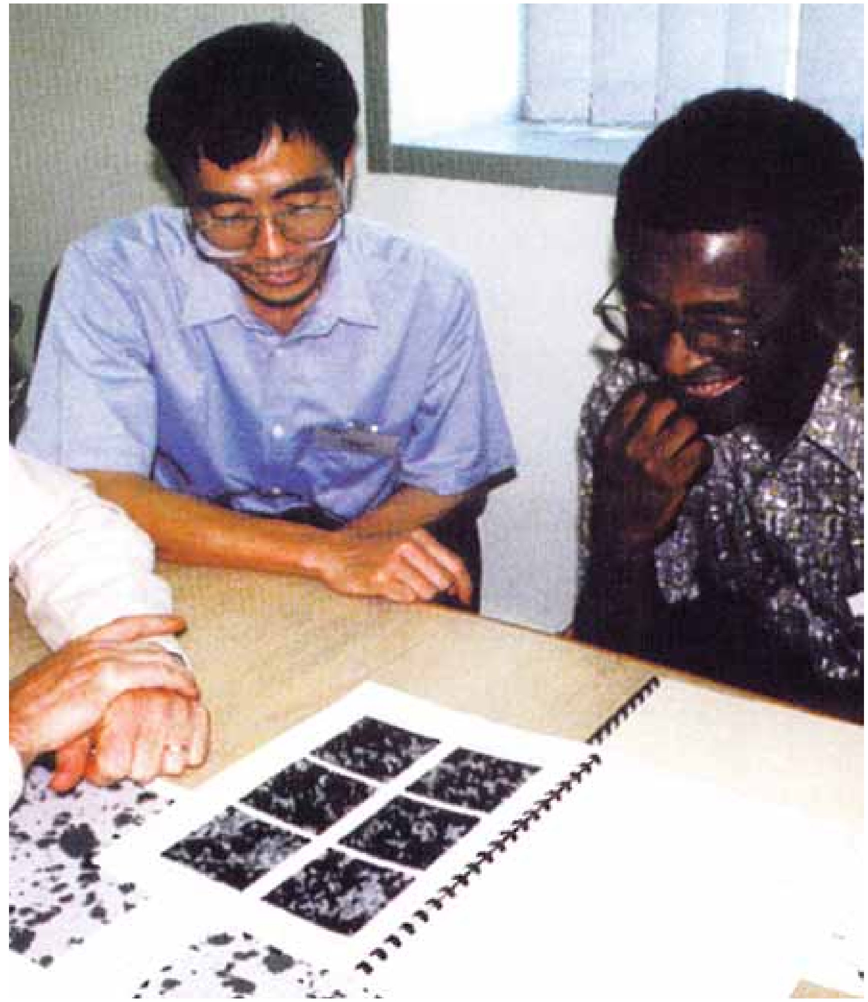
It's clear the JKMRC has made a difference well beyond dollars and cents.

VALUE ADDED

The research at the JKMRC addresses real problems.

Whatever official monetary figures have been put on the ground-breaking work of the JKMRC over 50 years, it would most likely be an underestimate.

If you were to identify five key inventions by the JKMRC, they would be JKSimMet, JKSimFloat, the Drop Weight Tester, Mineral Liberation Analyser, and of course, Project P9.



Those who enjoy being challenged and inspired have often found the JKMRC to be the perfect environment

At the time of print UQ was displaying its excellence across many spheres by being at the front of COVID vaccine research

P9 really was the cornerstone for the JKMRC and still underpins much of why the centre has become world-famous.

Although the Global Financial Crisis from 2007 had a very notable impact on the centre and certainly brought new challenges, if anything its survival and resurgence post the crisis is due to how closely linked the JKMRC is to industry.

REDEFINED

The role of the JKMRC has been redefined over time to respond to the continuously changing environment in which it operates.

As the Institute has grown, industry partners now work through centres like the JKMRC to access the expertise of SMI and whole University.

UQ's areas of strength extend beyond the traditional mining related areas of engineering, geosciences and mineral processing, enabling access to emerging technologies in biology, the social sciences, law and psychology. UQ is immensely strong in all those areas ranking consistently in the top 50 globally.

The JKMRC started as a unit detached from the University because they wanted to be industry-led and that was absolutely revolutionary at the time. Modern partnerships between universities, industry and non-government organisations call for closer connections and Professor Tim Napier-Munn previously acknowledged the bridging work provided by Professor Don McKee in bringing the JKMRC closer to UQ.

LISTENING TO INDUSTRY

Director Rick Valenta looks back over the common threads that bind the work of the JKMRC together across five decades.

For all that has changed, there are a couple of clearly identifiable things in his mind that define the work undertaken in the centre's name.

"The thing that comes through to this day is the vital importance of us going out and listening intently to industry," says Valenta.

"In order to be successful, that's been essential…things like sending students out to sites, establishing strong, close and lasting connections with key industry personalities.

"It's interesting revisiting the history because those relationships have not been formed the same way you would in other industries, where you'd send out someone who could 'talk the talk' for long liquid lunches to win people over.

"It's come about through genuine passion for the industry, the science behind it, wanting to improve things, and a deep knowledge, sometimes which is shared by only a select few people.

"Those relationships have been almost symbiotic, as if we are almost seconded into the partner organisations. In fact, I'm not long back from helping one partner conduct job interviews for a vacancy they have.

"We completely share our objectives. It's not a basic, transactional relationship."

As is exhibited elsewhere in this book, the unflinching work ethic of the staff and students has been another strong feature throughout the JKMRC.

It follows the popular quote 'Do what you love and you'll never work a day in your life'.

"A lot of people at JKMRC don't feel like they're doing a nine-to-five job," says Valenta.

"One common comment is that people don't do their job for the pay. They are at the JKMRC to do what they are passionate about, which they'd do if they weren't being paid anyway.

"It's great to have such passionate people because it convinces our partners that we want to reach the 'promised land' as much as they do.

The Fimiston Open Pit in Western Australia, previously Australia's largest open-cut gold mine, Photo - Brian Voon Yee Yap

Undertaking a seismic scan in an underground tunnel

"Whether someone feels really strongly about using less water in processing, improving performance of a particular piece of equipment through revolutionary physics, or ensuring nothing of value is lost in the tailings, you see that focused mindset rise to the fore.

"We're in a place where it pays dividends to be obsessive.

"You don't just finish a project and move on. Often, we are receiving data from one project and thinking of a whole bunch of interesting research areas that might be possible down the track.

"Quite a few times it's come to the end of the timeline for a project and our partner is happy and someone within the JKMRC has said 'Actually, do you mind if I keep going with this?'.

"There's that desire to follow it through to the next stage and explore what else is on the horizon which might change the way things can be done."

GRABBING THE FUTURE BY THE TAILINGS

A broad range of experts interviewed for this book were of the opinion that tailings – the unwanted offcasts of mining – would be a major area of focus for the future.

"There's a large amount of metal in waste dumps that can now be recovered due to technological advances," said Professor Neville Plint.

"There's going to be incredible value in very selective chemistry that enables selective separation technologies, resulting in operational and capital efficiency gains.

"Beyond what unutilised metals remain in tailings, what value can be derived from the remaining material that has been mined? Could it become aggregate for our roads, or for use in building materials?"

As Professor Rick Valenta said, the question on everybody's lips was "How do we eliminate tailings altogether?".

"Enormous tailings storage facilities are a product of economy-of-scale issues and a mindset that creates devastation and feeds negative outcomes and perceptions around mining," said Professor Valenta.

"If the most celebrated projects are the biggest, fattest things, then we're really in the age of dinosaurs, aren't we?

"There are many case histories that show that the biggest projects are usually the ones with the biggest cost and time over-runs, so there are multiple problems in being grandiose.

"The JKMRC is focusing on a whole piece of work around mineral processing that optimises value not only in terms of efficiency and profit, but also in terms of project environmental and social impacts. This approach could lead to a future of smaller, more efficient and lower impact projects."

UNEXPLORED OPPORTUNITIES

The story of how Professor Malcolm Powell came into mining still rings true as the JKMRC embarks on the 2020s and beyond.

From an initial reluctance to be involved in mining, Professor Powell discovered so many facets that were different to expectation and that were yet to be fully explored.

"I soon discovered there were lots of fantastic opportunities in mining," said Powell.

"On first glance, as an outsider, you think it's an industry that has it all worked out.

"Once you're inside, you discover this complex, amazing world where a lot of things truly haven't been perfected.

"As a researcher, there is this huge treasure trove of potential. I haven't been disappointed by how many opportunities are out there, that's for sure.

project hits a snag

[illegible]0 grant but no takers

DR DAVID Rowlands has half a million dollars to spend on research, and he cannot find one Australian graduate to employ on the project.

The money represents the largest grant ever given to a university department in Australia but the three research scholars urgently needed to begin work on the project will probably come from overseas.

The grant has been given to Queensland University's Julius Kruttschnitt Mineral Research Centre by a group of mining companies. It is to finance research on a method not only to predict how exploding rock will fragment but to control the size of ore and rock fragments.

As head of the university's Department of Mining and Metallurgical Engineering, Dr Rowlands is responsible for supervising research staff appointments to the project.

"Every mining nation is trying to tackle this problem, but no other university overseas has been given this sort of money," he said yesterday.

"We have applicants from all over the world but not one from Australia.

"The unfortunate problem with this is we will be training overseas people to solve a problem, but the expertise they gain will be going out of Australia."

The centre is offering $5500 a year to research scholars on the project — compared with a normal grant of about $4300. In addition, there are benefits for dependants and other allowances.

"This question of rock fragmentation is a very real world problem," Dr Rowlands said. Every operation subsequent to the actual breaking of the rock depends on that initial fragmentation.

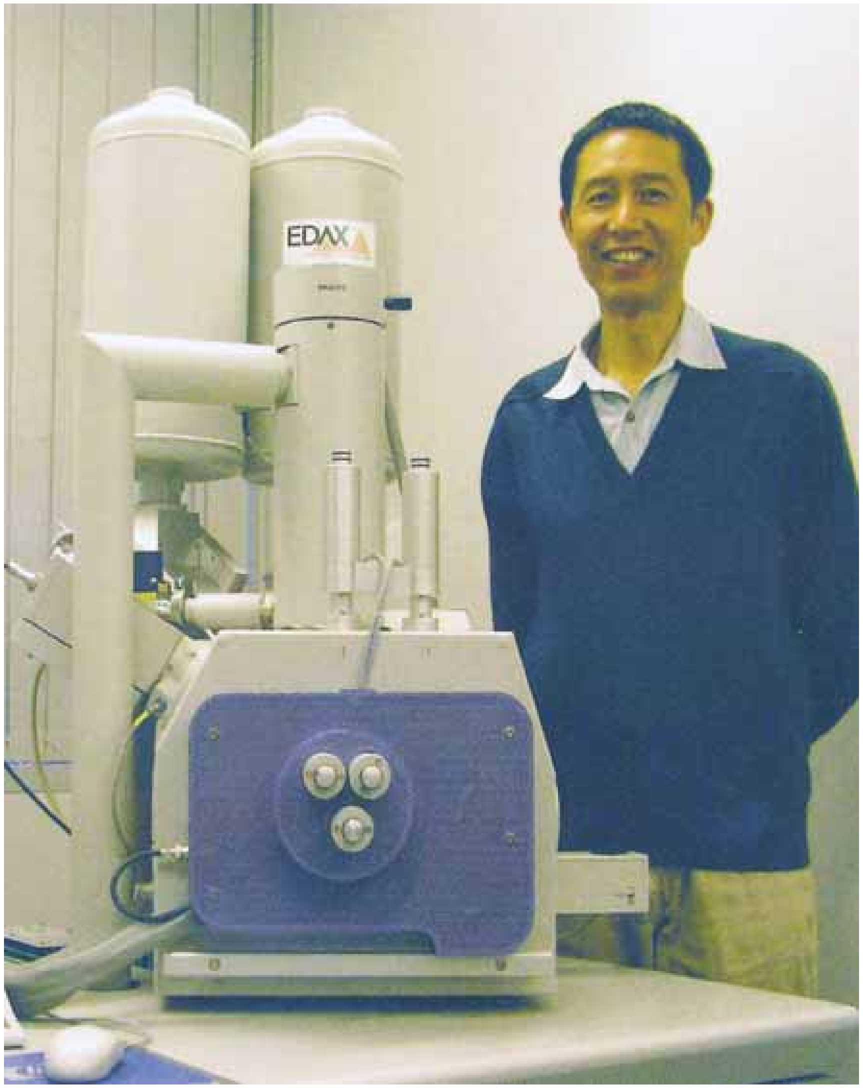
"It dictates the size of underground roadways, loading vehicles, crushing equipment and transportation.

"In open-cut mining it controls the size and operation of the dragline.

"Considering the cost of a dragline, which has to be ordered years in advance, you are really talking money if you get the wrong size."

DR ROWLANDS ponders the lack of local graduates to undertake fragmentation research which could lead the world

Times have certainly changed since this forlorn newspaper article



The late Ying Gu with the Mineral Liberation Analyser (MLA)

"It's 36 years since I started in this industry and the opportunities are endless for improving, understanding and reinventing.

"That last part – reinventing – is what keeps me engrossed.

"We can't dictate our assets in mining, because we must accept what nature has given us, and where it has given it to us, which makes it different to a lot of other industries.

"In the end it comes down to good physics and rethinking the way things have been done."

TRANSFORMING YOURSELF TO TRANSFORM THE INDUSTRY

Malcolm Powell talked about the "classic trap for academics" – that is the desire for people to research what they have a personal interest in, rather than the topic that is of most benefit to humankind.

Powell and others believed it was the ability of JKMRC to clearly focus on the latter, rather than the former, which set it apart.

"I guess we all have our pet topics, but I've tried really hard to impress that we can't get hung up on them. We have to look at the areas where the need really exists," said Powell.

"You've got to constantly reinvent yourself. If you're in research, you're in the field of development. They go hand-in-hand.

"JKMRC has tried to transform the industry on a number of fronts. You realise that you need to transform yourself in order to change the thing you want to transform.

"There are some deep challenges that come with achieving that and becoming agents for transformation, whether that be in the way you perceive yourself, the way others perceive you and your expertise, right through to things like the manner in which funding is allocated.

"You can't be a follower. You have to listen to industry at the same time as leading industry, which can be a tricky balance."

Earlier researcher Professor Edwin T Brown made a similar observation when consulted for this book, saying that mindset had been entrenched over decades.

"The JKMRC was the dominant research group at the University for a long time," said Brown.

"The thing that made it unique was that it was self-funded, due to Lynch's links with industry.

"Most other academics at that time didn't want to do projects of interest to industry – they just wanted industry to be interested in what they felt like doing."

POINT OF DIFFERENCE

By pure virtue of the people who inhabit the walls of the JKMRC, it is quite unlike most other places in the world.

"There's a combined 500 years of mining industry work experience in this hallway," Professor Rick Valenta said.

"If you have any problem, you can walk down to the next door and speak with someone who has not only just been involved with that area, but has been right in the middle of it…in the thick of it.

"That's important for multiple reasons, not the least because you can get the truth of a situation from someone who has seen it inside-out and understands the weaknesses and peculiarities.

"Sometimes when you're reading literature from an expert, it doesn't reveal the full picture and you get some numbers or facts that have simply propagated over time, without being tested.

"We call on people who really know what's going on and what has gone on.

"Another point of difference is that a lot of the big contractors in the mining world are very conservative in their approaches and don't want to get too creative. They stay alive by taking 'safe' options.

Continuing to share ideas and see things from different vantage points will remain a strength of the JKMRC


Professor Neville Plint looks eagerly towards the future

"To a certain extent, the JKMRC is paid to come up with wacky ideas and be a bit different.

"For instance, we might look at places where people decided mines weren't viable, then think about what the challenges are and if there may be creative solutions that haven't been thought of previously."

KNOWLEDGE SHARING

An element that becomes apparent as you trawl through the many accomplishments of the JKMRC is the unselfish way in which it shared ground-breaking knowledge.

While it's true that the JKMRC commercialised several of its greatest capabilities via JKTech, it consistently released new information into the public domain when private enterprise might have held it under lock and key to try and gain a competitive advantage.

"Our purpose is to inspire and develop people, by conducting challenge lead research that is used by our stakeholders. We have an obligation to share the new knowledge that we generate through our research activities," said Professor Neville Plint.

PhD students come from around the world and eventually return to their home country and, in many cases, they continue to develop their research work.

Professor Rick Valenta had a similar view when asked about the JKMRC's benevolence in sharing its knowledge.

"Quite a lot of what we've developed at the JKMRC has been done under arrangements where the partner company owns the information at the end of the research" Professor Valenta said.

"The value for the company is to apply that knowledge, but the value for us is to publish it.

"Most areas of universities are measured by their output in publications. That's the creation of new knowledge.

"I'd say we're slightly different in that the measure of our advancements is linked to the take-up of our knowledge within the industry. The measure of how good our work is, is by how much of a difference it makes to industry.

"As long as we continue to attract the best people from all around the world, the JKMRC will continue to make a massive impact on mining on a global scale, albeit in new ways that adapt to – and reflect – the challenges of the particular time."

JKMRC Alumni

Alumni No.	Initials	Surname	Year	Degree
1	Alban J	Lynch	1964	PhD
2	David E	Moore	1964	PhD
3	T C	Rao	1966	PhD
4	Phil D	Bush	1967	PhD
5	John R	Braes	1969	MSc
6	P.T.	Isles	1969	MEngSc
7	Don J	McKee	1969	MEngSc
7	Don J	McKee	1972	PhD
8	Mal J	Lees	1970	MSc
8	Mal J	Lees	1973	PhD
9	Eugene	Gallagher	1972	MSc
9	Eugene	Gallagher	1976	PhD
10	N W (Bill)	Johnson	1972	PhD
11	G.G.	Stanley	1972	ME
11	G G	Stanley	1974	PhD
12	W J (Bill)	Whiten	1972	PhD
13	Peter	Wickham	1972	MEngSc
14	Robert H	Cuttriss	1973	MEngSc
15	Geoff A	Gault	1973	MSc
15	Geoff A	Gault	1975	PhD
16	D R	Marlowe	1973	MSc
17	S K (Komar)	Kawatra	1974	PhD
18	Emmy V	Manlapig	1975	MEngSc
18	Emmy V	Manlapig	1977	PhD

Alumni No.	Initials	Surname	Year	Degree
19	Grant C	Thorne	1975	PhD
20	Ronald A	Wiegel	1976	PhD
21	John S	Hall	1977	PhD
22	Rob D	Morrison	1977	PhD
23	Geoff A	Duckworth	1978	MEngSc
23	Geoff A	Duckworth	1981	PhD
24	K R	Leach	1978	MSc
25	Karri	Nageswararao	1978	PhD
26	J F	Thompson	1978	MSc
27	Mark E	White	1978	PhD
28	Ray J	Doherty	1979	MEngSc
29	Nihal	Liyanaarachchi	1980	MSc
30	Robert H	Allan	1981	PhD
31	Tom H	Kleine	1981	MSc
31	Tom H	Kleine	1988	PhD
32	Shaun A	Mays	1982	MSc
33	Howard	Askew	1983	PhD
34	Sylvester E A	Awachie	1983	PhD
35	Ivan D	Cauley	1983	MEngSc
36	Nigel p	Cleminson	1983	PhD
37	Fred W	Hess	1983	PhD
38	Andrew J	Thornton	1983	MSc
38	Andrew J	Thornton	1986	PhD
39	Mike G	Casey	1984	MEngSc

Alumni No.	Initials	Surname	Year	Degree
40	Geoff J	Lyman	1984	PhD
41	Bernard A	O'Brien (Oil)	1984	MSc
42	Carol A	Smith	1984	PhD
43	John	Turner	1984	MSc
44	David W	Lauder	1985	MSc
44	David W	Lauder	1989	PhD
45	Cameron K	McKenzie	1985	PhD
46	S S	Narayanan	1985	PhD
47	Trevor A	Nicholson	1985	MSc
47	Trevor A	Nicholson	1996	PhD
48	Iain A	Scott	1985	MSc
48	Iain A	Scott	1990	PhD
49	David M	Wiseman	1985	MSc
50	Robert A	Alford	1987	MEngSc
50	Robert A	Alford	1991	PhD
51	Jeff J	Dawes	1987	PhD
52	William A	Hutton	1987	MEngSc
53	Mark E	Armstrong	1988	MEngSc
54	Jon J	Davis	1988	PhD
55	Jeffrey M	Graham	1988	MEngSc
56	Dean	Ilievski	1988	ME
57	Brett M	King	1988	MEngSc
58	Kam	Leung	1988	PhD
59	Jonathan D	Lilly	1988	MSc
60	Phil	Baguley	1989	MEngSc
61	Brad M	Bulow	1989	MEngSc
62	John H	Heilig	1989	PhD

Alumni No.	Initials	Surname	Year	Degree
63	Toni	Kojovic	1989	PhD
64	Jan S	Anderson	1990	MEngSc
65	Robin D	Evans	1990	MEngSc
66	Brigitte	Lacouture	1990	MEngSc
67	Belarmino	Lira	1990	PhD
68	Steve	Morrell	1990	ME
68	Steve	Morrell	1993	PhD
69	Norman	Paley	1990	MEngSc
70	Rui Xuan (Richard)	Rong	1990	PhD
71	Rui Lin	Yang	1990	PhD
72	Shinichi	Akutagawa	1991	PhD
73	Oscar M	Castro	1991	MEngSc
74	Gideon P	Chitombo	1991	PhD
75	Clarito P	Corpuz	1991	ME
76	W M (Bill)	Finch	1991	MSc
77	Andrew J	Jonkers	1991	MEngSc
78	Cameron C	Russell	1991	MEngSc
79	Ernesto	Villaescusa	1991	PhD
80	Weizhao (Karen)	Yu	1991	MEngSc
81	W R (Bill)	Adamson	1992	PhD
82	Adrian D	Dance	1992	PhD
83	David W	Ginsberg	1992	PhD
84	Pierre H J	Grouhel	1992	MSc
85	Mark C	Nott	1992	MEngSc
85	Mark C	Nott	1997	PhD
86	Zhu	Rui	1992	MEngSc
86	Zhu	Rui	1997	PhD

Alumni No.	Initials	Surname	Year	Degree
87	Andy W	Stradling	1992	PhD
88	Rohit K	Tuteja	1992	MEngSc
89	Chris J	Wood	1992	PhD
90	Zhang	Yimin	1992	PhD
91	Alan R	Cameron	1993	PhD
92	Wendy J	Dawson	1993	MEngSc
93	Harry R A	Exelby	1993	MSc
93	Harry R A	Exelby	1997	PhD
94	Jewette H	Masinja	1993	PhD
95	Arif S	Siregar	1993	PhD
96	Prapun	Sunpetsiri	1993	MEngSc
97	Li	Tao	1993	PhD
98	Mike W	Thomas	1993	MEngSc
99	Pat A	Walker	1993	PhD
100	Ray	Wedmaier	1993	PhD
101	David M	Weedon	1993	PhD
102	Darren J	Edward	1994	MEngSc
103	John P C	Mutambo	1994	MEngSc
104	Kurt R P	Petersen	1994	MSc
105	K S	Sarma	1994	PhD
106	John	Willis	1994	PhD
107	YueJun	Cai	1995	MEngSc
108	G	Chapa	1995	MEngSc
109	Nenad M	Djordjevic	1995	PhD
110	Mark S	Duffy	1995	MEngSc
111	Derek	Kowald	1995	MSc
112	Michelle	Li	1995	PhD

Alumni No.	Initials	Surname	Year	Degree
113	R M	Selamat	1995	PhD
114	Frank	Shi	1995	PhD
115	Godfrey P T	Dzinomwa	1996	PhD
116	Stephen	Gay	1996	PhD
117	Erik	Isokangas	1996	PhD
118	Ladislav	Kocis	1996	PhD
119	Fernando	Tapia-Vergara	1996	MEngSc
120	Marco A	Vera	1996	MEngSc
120	Marco A	Vera	2002	PhD
121	Cameron	Briggs	1997	PhD
122	Gary W	Elworthy	1997	ME
123	V V	Ram Rao	1997	MEngSc
124	Kristin	Stewart	1997	PhD
125	Isaac	Asomah	1998	PhD
126	Barun	Gorain	1998	PhD
127	Khoi K	Nguyen	1998	PhD
128	Clint G	Scott	1998	MEngSc
129	Ian	Stephenson	1998	PhD
130	Walter	Valery	1998	PhD
131	Jinhong	Xiao	1998	PhD
132	Ian	Brunton	1999	MEngSc
133	Homero	Delboni	1999	PhD
134	Michael	Dunglison	1999	PhD
135	Krzysztof	Golab	1999	PhD
136	Aleksandar	Jankovic	1999	PhD
137	Richard	Kelly	1999	PhD
138	David	Peel	1999	PhD

Alumni No.	Initials	Surname	Year	Degree
139	David	Rahal	1999	MEngSc
140	John	Rayner	1999	PhD
141	Orivaldo	Savassi	1999	PhD
142	Luis A	Tondo	1999	MEngSc
143	Mark	Wilmot	1999	MEngSc
144	Debbie	Zhang	1999	PhD
145	Jonathan	Keith	2000	PhD
146	Yvonne	Kolatschek	2000	MEngSc
147	Yun Tai	Man	2000	PhD
148	Lemas	Pangum	2000	PhD
149	Vi-Hoa	Tran	2000	PhD
150	Julia	Warder	2000	MSc
151	Predrag	Bojcic	2001	PhD
152	Neal	Harries	2001	PhD
153	Shaun	Lymbery	2001	PhD
154	Ning	Zhang	2001	MEngSc
155	Widi	Ashari	2002	MEngSc
156	George	Banini	2002	PhD
157	Sanjeeva	Latchireddi	2002	PhD
158	Clare	Mawdesley	2002	PhD
159	Vijay	Subramanian	2002	PhD
160	Mike	Daniel	2003	MEngSc
160	Mike	Daniel	2007	PhD
161	Brian	Eadie	2003	PhD
162	Arun	Majumder	2003	PhD
163	Mary	Ng	2003	PhD
164	Sebastian	Tello	2003	MEngSc

Alumni No.	Initials	Surname	Year	Degree
165	Ridho	Wattimena	2003	PhD
166	Marcin	Ziemski	2003	PhD
167	Gary	Cavanough	2004	PhD
168	Mingxiao	Dou	2004	PhD
169	S	Esen	2004	PhD
170	Syed	Hashim	2004	PhD
171	Daniel	Obeng	2004	PhD
172	Gavin	Power	2004	PhD
173	Kerrigan	Rich	2004	MSc
174	S	Vianna	2004	PhD
175	Michael	Callan	2005	PhD
176	German	Flores	2005	PhD
177	Alan R	Guest	2005	PhD
178	Priyanthi	Hapugoda	2005	MPhil
179	Zeljko	Krco	2005	MPhil
180	Italo	Onderra	2005	PhD
181	Penny	Stewart	2005	PhD
182	R G	Coleman	2006	PhD
183	Adrian	Halim	2006	PhD
184	J	Hall	2006	MPhil
185	A D	Latti	2006	PhD
186	Simon	Michaux	2006	PhD
187	Edy	Sanwani	2006	PhD
188	David R	Seaman	2006	PhD
189	Dan	Alexander	2007	PhD
190	Raul	Castro	2007	PhD
191	Rachel A	Hawkins	2007	MPhil

Alumni No.	Initials	Surname	Year	Degree
192	Marko	Hilden	2007	PhD
193	Wally	Xu	2007	PhD
194	Will	Jansen	2008	PhD
195	Aaron	Power	2008	MEngSc
196	Murat	Cakici	2009	MPhil
197	George	Leigh	2009	PhD
198	Juan	Reyes-Bahena	2009	PhD
199	Kym	Runge	2009	PhD
200	Xiaofeng	Zheng	2009	PhD
201	Steve	Larbi-Bram	2010	PhD
202	Simon	Welsby	2010	PhD
203	Narasimha	Mangadoddy	2010	PhD
204	Zeljka	Pokrajcic	2010	PhD
205	Ricardo	Pascual	2010	PhD
206	Luke	Keeney	2010	PhD
207	Tim	Vizcarra	2011	PhD
208	Aung	Min	2011	PhD
209	Cathy	Evans	2011	PhD
210	Fiesal	Musa	2011	PhD
211	Carlos	Vanegas	2011	PhD
212	Rod	Hocking	2011	PhD
213	Paul	Botman	2011	MPhil
214	Can	Ozer	2011	PhD
215	Graham	Sheridan	2011	MPhil
216	Rena	Varadi	2011	PhD
217	Reyhaneh	Tabatabaei	2012	PhD
218	Richard	Hartner	2012	PhD

Alumni No.	Initials	Surname	Year	Degree
219	Natasha	Danoucaras	2012	PhD
220	Tam	Pham	2012	PhD
221	Vlad	Rizmanoski	2012	PhD
222	Vlad	Jokovic	2012	PhD
223	Grant	Ballantyne	2012	PhD
224	Eric	Wang	2012	PhD
225	Erico	Tabosa	2012	PhD
226	Brigette	Comley	2013	PhD
227	Michael	Larson	2013	MPhil
228	Eiman	Amini	2013	PhD
229	Ana Maria	Rojo	2013	MPhil
230	Gerson	Sandoval	2013	PhD
231	Marcos	Bueno	2013	PhD
232	Rajiv	Chandramohan	2013	PhD
233	Geoff	Genn	2013	PhD
234	Cristian	Carrasco	2013	MPhil
234	Cristian	Carrasco	2017	PhD
235	Paul	Toor	2014	MPhil
236	Graham	Long	2014	MPhil
237	A	Rodrigues	2014	MPhil
238	Bianca	Newcombe	2014	PhD
239	Fraser	Burns	2014	MPhil
240	Chris	Akop	2014	MPhil
241	Mitesh	Chauhan	2014	PhD
242	Snezana	Bajic	2015	PhD
243	Xumeng	Chen	2015	PhD
244	Carl	Masuret	2015	MPhil

Alumni No.	Initials	Surname	Year	Degree
245	Daniel	Mitchell	2015	MPhil
246	Weiran	Zuo	2015	PhD
247	Nestor	Cruz	2016	PhD
248	Naren	Vijayakumar	2016	MPhil
249	Eugene	Louwrens	2016	PhD
250	Jocelyn	Quinteros	2016	PhD
251	Tamsyn	Parker	2016	MPhil
252	Ashleigh	Collins	2016	PhD
253	Md Maruf	Hasan	2016	PhD
254	Kate	Tungpalan	2016	PhD
255	Jun	Meng	2016	PhD
256	Riza	Mariano	2016	PhD
257	Chao	Li	2016	PhD
258	Greg	Wilkie	2016	Phd
259	Baris	Yildirim	2016	PhD
260	Francois	Vos	2017	PhD
261	Lei	Wang	2017	PhD
262	Fatemeh	Saeidi	2017	PhD
263	Vannie	Resebal	2017	PhD
264	Joseph	John	2017	PhD

Alumni No.	Initials	Surname	Year	Degree
265	Rasyid	Muhammad A	2017	MPhil
266	Yogesh	Reja	2017	MPhil
267	Maedah	Tayebi-Khorami	2017	PhD
268	Ping	Yu	2017	PhD
269	Nerrida	Scott	2017	PhD
270	Bianca	Foggiatto	2017	PhD
271	Sayuri	Katagiri	2017	MPhil
272	John	Thella	2018	PhD
273	Wei	Huang	2019	PhD
274	Erica	Avelar	2020	PhD
275	Juan Jose	Frausto-Gonzalez	2020	PhD
276	Farhad	Faramarzi	2020	PhD
277	Peter	Legge	2020	MPhil
278	Pia	Lois- Morales	2020	PhD
279	Raoni	Antunes Ferreira Lage	2020	MPhil
280	Bernard	Agbenuvor	2020	MPhil
281	German	Figuero	2020	PhD
282	Constanza	Ivonne Paredes Buje	2020	PhD

JKMRC Glossary

ACARP – The Australian Coal Industry's Research Program

AIME – Australian Institute for Mining Engineers

AMIRA – Australian Mineral Industries Research Association Limited

AMSRI – Australian Mineral Science Research Institute

ASARCO – American Smelting and Refining Company

ARC – Australian Research Council

ASHSCAN – Provides real-time, continuous data on total ash content in coal

AusIMM – Australasian Institute of Mining and Metallurgy

BART – Blasting and Reinforcement Technology

BRC – WH Bryan Mining and Geology Research Centre

CIMM - Centro de Investigacion Minera y Metalurgia in Santiago, Chile

CMLR – Centre for Mined Land Rehabilitation

CMTE – Centre for Mining Technology and Equipment

CRC – Cooperative Research Centres

CSIRO – Australia's Commonwealth Scientific and Industrial Research Organisation

CSRM – Centre for Social Responsibility in Mining

CWiMI – Centre for Water in the Minerals Industry

DMC – Dense Medium Cyclone

Drop Weight Tester – Also known as JKDWT, this equipment establishes the relationship between energy input and product fineness in breakage.

Finney's Hill – The geographical location of the Julius Kruttschnitt Mineral Research Centre

FORTRAN – Contraction of Formula Translation, a computer programming language

GEM Project – Geometallurgical Mapping and Mine Modelling Project

ICS – International Caving Study

Indooroopilly – The suburb of the Julius Kruttschnitt Mineral Research Centre

IP – Intellectual Property

JKVBOC – JK Value Based Ore Control. An engineering tool to simulate and predict blast movement in open pit mining to make proactive decisions

JKMBal – A mass balancing system developed for wider commercial application

JKMetAccount – Software for tracking metal and mineral products through mining, enrichment, refining and distribution

JKMRC – Julius Kruttschnitt Mineral Research Centre

JKSimBlast – Software that designs blasting programs faster than Autocad

JKSimDM – JK Dense Medium Simulation for separation circuits

JKSimFloat – Software that enables flotation plant operators to optimise throughput, grade and recovery.

JKSimMet - Software for the analysis of comminution and classification circuits

JKSimSand – Software for mineral sands simulation

JKTech – Company formed in 1985 to maximise commercial opportunities from JKMRC research and developments

MIM – Mount Isa Mines

MISHC – Minerals Industry Safety and Health Centre

MLA – Mineral Liberation Analyser. An automated system for identifying minerals and quantifying a wide range of mineral characteristics.

NBHC – New Broken Hill Consolidated

NERDDC – National Energy Research Development and Demonstration Council

OPEC – Organisation of Petroleum Exporting Countries

P9 – Also known as the Mineral Processing Project, it was highly influential in JKMRC's early development and subsequent versions have continued to be an important pursuit to this day

QEM*SEM – Creates maps of a specimen surface using a high-energy electron beam

SEM – Scanning Electron Microscope

SMI – Sustainable Minerals Institute

SMI-ICE-Chile – The Sustainable Minerals Institute International Centre for Excellence in Chile

UCT – University of Cape Town

Uniquest – The commercialisation arm for research and inventions produced by The University of Queensland

UQ – The University of Queensland

WMC – Western Mining Company

HISTORY OF THE JULIUS KRUTTSCHNITT MINERAL RESEARCH CENTRE

1960 - 1990

1962
Amira P9 Project
Automatic control systems for mineral grinding circuits

1964
1st Higher Degree Awarded

1968
Amira P9 Project
Automatic control systems for flotation circuits

1970
First Funding for JKMRC
Mt Isa Mines Ltd provides funding to establish the JKMRC

1971
JKMRC Official Opening
Professor Alban Lynch is the first Director of JKMRC

1971
Bill Whiten Acting Director
Alban Lynch visits University of Minnesota

1974
Coal Preparation Research

1977
Blasting Research commences

1985
JKSimMet
Grinding and crushing simulation software

1987
JKTech
Foundation of technology transfer group

1988
Mineral Sands Research

1990 -2000

1990
Director Change
Professor Don McKee becomes the second Director of JKMRC

1991
Drop Weight Tester

1992
100th Higher Degree Awarded

1993
JKSimFloat
Flotation circuit simulation software

1996
First and Second Monographs Published
'Mineral Comminution Circuits'
'Open Pit Blast design'

1997
Director Change
ProfessorTim Napier-Munn becomes the third Director of JKMRC

1998
Invention of MLA
Mineral Liberation Analyser
Mine to Mill Research
International Caving Study Group commences

2000 - 2010

2001
Sustainable Minerals Institute established

JKTech Incorporated

2003
Third Monograph Published
'Block Caving Geomechanics'

2004
CRC for Sustainable Resource Processing

2005
GeM Project commences
Director Change
Professor Ben Adair becomes the fourth Director of JKMRC
Chair in Sust. Commin established

2006
AMSRI (Australian Mineral Science Research Institute) Project commences

2007
Chair in Flotation established
HVP Technology Research
High Voltage Pulse technology

2008
Fourth Monograph Published
'Metal balancing and reconciliation'

2009
Asia Pacific Partnership Coal Project
200th Higher Degree Awarded

2010 - 2020

2010
Director Change
Professor Geoff Gault becomes the fifth Director of JKMRC
MCRF
Mineral Characterisation Research Facility built
Rio Tinto Centre for Advanced Mineral Seperation

2011
MSI (Mineral Separability Indicator) developed

2012
Anglo American Centre for Sustainable Comminution established
Director Change
Professor Wayne Stange becomes the sixth Director of JKMRC
50th Anniversary of the AMIRA P9 Project

2013
Director Change
Dr Chris Fountain becomes the (Acting) Director of JKMRC

2014
25th Anniversary of the Ian Morley Prize
Fifth Monograph Published
'Statistical methods for mineral engineers'

2015
Director Change
Professor Alice Clark joins SMI as Director of Production Centres (JKMRC and BRC)
SMI-JKMRC
Initiation of integrated programs across JKMRC and SMI

2016
WH Bryan Research Centre (BRC) Relocates to Indooroopilly Site

2017
Seventh Monograph Published
'Guidelines on caving mining methods'
Industry Placement Program
Student field/site placement program established
A MIRA P9Q Project Commences

2018
Director BRC
Professor Rick Valenta appointed Director BRC

2019
Director Change
Assoc Prof Marcin Ziemski becomes the (Acting) Director of JKMRC

2020
JKMRC 50 year anniversary

Director Change
Professor Rick Valenta becomes Director of the Production Cetnres

The University Of Queensland
AUSTRALIA
CREATE CHANGE