Centennial reflections of the Department of Mining Engineering at the University of the Witwatersrand

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Synopsis

On the one-hundredth anniversary of the founding of the South African School of Mines, this paper presents a historical review of the tertiary mining education carried out by the School of Mines in Kimberley and the subsequent institutions in Johannesburg. In addition to recording and evaluating a century of mining education, it describes the current activities of the Department of Mining Engineering at the University of the Witwatersrand, which is believed to be the natural successor to the School of Mines.

The comparison of earlier and contemporary academic mining activities reflects a gradual transition from the educational philosophy and objectives of a school of mines to those of a modern university department. In the conclusions, some aspects of the educational effort expended during the past hundred years are briefly highlighted.

Introduction

According to Orr[1], the first recorded tertiary education in mining in South Africa started on 10th August, 1896, at Kimberley in the newly established South African School of Mines. Students who enrolled for the course had to be in possession of a university pass in the pure sciences, and instruction in these sciences was provided, over a period of two years, by the South African College, Cape Town. After one year's study of mining and allied subjects in the School of Mines, students were required to spend a further year on the Witwatersrand goldfields, where they were expected to receive additional mining tuition. Those who successfully completed the four-year programme were awarded a diploma in mining engineering by the University of the Cape of Good Hope.

The creation of the School of Mines initiated a chain of events that eventually resulted in the establishment of the University of the Witwatersrand (Wits). After the South African School of Mines had been transferred to Johannesburg, it underwent a number of name-changes, and its character was modified from a school of mines to that of a technical institution covering a broader field of engineering studies and, finally, to that of a fully fledged university.

During these changes, the provision of mining education at a tertiary level was always the primary objective of the appropriate institution, under whatever name it was operating. However, as the number of disciplines catered for increased within the successive institutions, an academic unit was established to facilitate the teaching of mining and metallurgy, and later on the mining courses only, thus giving a full and independent identity to the Department of Mining Engineering.

Because of its origin, its history, and the nature of the education provided, it is believed that the Department of Mining Engineering at the University of the Witwatersrand is the natural successor to the original South African School of Mines. This direct line of succession charges the Department, its academic staff, and present student body with the responsibility of preserving the academic objectives, and fostering the traditions and legacies of the South African School of Mines. For these reasons, the Department celebrates the anniversary of the establishment of the South African School of Mines one hundred years ago.

As part of the centennial celebrations, it is appropriate to explore and record some aspects of the history of the relevant academic institutions, to evaluate the activities of the Department, and to review its current responsibilities for the present and not-too-distant future. It is the purpose of this paper to meet these objectives and to record the status of the present undertaking.

Although the authors have attempted to combine a description of relevant past events with an interpretation as they see them, this study is not intended to be a comprehensive history of the institutions involved. There are two reasons for this. The first one is that the authors' main interest lies in the historical events associated with the academic activities directed to the education of mining students only. The second reason is that an excellent and detailed historical account of the pre- and early-university periods of Wits by Murray[2] is already available. Consequently, the present study

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is based mainly on published sources, rather than on original documents. In dealing with relatively recent events, appropriate university or departmental records were utilized.

The Kimberley Years

The history of southern Africa in the second half of the 19th century is characterized by the conflicting political and economic interests of the peoples inhabiting the sub-continent. One of the prominent components of these conflicting interests was brought about by the extension of European influence and the conclusion of British political supremacy over southern Africa. An equally significant factor was the birth and growth of the Afrikaner people, with their own national consciousness. The interests of the various indigenous peoples and their political and economic influence on the events shaping the history of the region represents the third important factor.

The various conflicting pressures were compounded by the opening up of the diamond fields at Kimberley in 1870 and, later on, in 1886, the discovery of gold on the Witwatersrand. From the perspective of this study, the rapid development of mining and the service industries in the last three decades of the century is of particular importance.

By 1890 the recovery of diamonds at Kimberley was becoming more difficult, and the increasing depth of mining brought about technical problems, including floodings and rockfalls. The haphazard system of mining by small prospectors was drawing to a close, and mining became more sophisticated owing to the mining methods used and the consolidation of claims. At the same time, gold mining on the Witwatersrand was well and truly established. As a result of the opening up of a great number of mines along a considerable length of the outcrop and the drilling of boreholes south of this outcrop, the vastness of the gold deposits was clearly demonstrated. The increasing depth of mining and, associated with it, the change in the nature of the orebody, brought about an urgent need for the introduction of complex mining and metallurgical technology.

Although a great deal of valuable mining experience, gained in California and Australia, was utilized in the early days of South African mining, the absence of locally educated mining engineers was very obvious by the last decade of the century. Therefore, conditions were ripe for the establishment of an institution of higher learning that would prepare young South Africans to become leaders of the rapidly developing mining industry.

The establishment of the South African School of Mines was influenced and supported by many eminent individuals, the government of the Cape Colony, De Beers Consolidated, and the two existing institutions of higher education in Cape Town. Among the outstanding individuals were the Prime Minister of the Cape, C. J. Rhodes, and P. D. Hahn, Professor of Chemistry at the South African College, who were keenly aware of the opportunities offered by the mining industry to young South Africans. The two existing institutions of tertiary education were the University of the Cape of Good Hope, the approved examining university for the Cape Colony, and the South African College, a teaching institution preparing students for both matriculation and university examinations.

Although the Council of the South African College proposed, in 1890, the establishment of a school of mines in Cape Town, the proposal was accepted by the Cape government only in 1894, with the significant modification that the school would be located in Kimberley. The prevailing political atmosphere in southern Africa and Rhodes's long-term plans, driven by his colonial ambitions, were responsible for the change in the location of the school.

After long discussions, the compromise scheme of study accepted was as follows. During the first two years, a course on basic sciences was provided in Cape Town by the South African College. At the end of the two-year study, students were required to pass the examination set by the University of the Cape of Good Hope. The third-year instruction in technical subjects and some practical training were given in the School of Mines at Kimberley. The fourth-year students were directed to spend a year in Johannesburg, where they received further technical instruction and practical training in gold mining. On successfully completing the fourth year of study, students were awarded a diploma in mining engineering by the University of the Cape of Good Hope.

For a number of reasons, the proposed scheme was modified in some respects. One of the major changes was the reduction of time the students spent on the Rand. Only the first group of fourth-year students spent a full year in Johannesburg. Despite the valuable assistance of the Chamber of Mines of the South African Republic in organizing the supervision of students and providing some lecturing facilities in Johannesburg, the practical training and further technical instruction could not be carried out as had been intended. Consequently, the time spent by students in Kimberley was increased to one-and-a-half years, and the duration of practical training on the Rand was reduced to six months.

The initial conditions at Kimberley were primitive, and the School was short of facilities, money, and staff. Some of these shortages were prevalent right through the Kimberley years. There were only two full-time members of staff, who carried out the theoretical and some of the practical instruction during the whole period of the School's existence. They were Professors J. G. Lawn and J. Orr. It should be recorded, however, that the School made extensive use of the technical and managerial staff of De Beers Consolidated in its practical training scheme.

In the first half of 1899, with the financial assistance of De Beers Consolidated and the Cape Colony, some new buildings and laboratories were added to the converted workshop and restaurant buildings used by the School. These purpose-built premises are shown in Figure 1. Thus, by the middle of that year, the teaching facilities and student accommodation improved to an acceptable level, and the organization of courses attained a certain degree of maturity. Unfortunately, the outbreak of the Anglo-Boer War, and the subsequent siege of Kimberley by the forces of the South African Republic and the Orange Free State in October 1899, disrupted the normal activities of the School and arrested the further development of this pioneer institution.

The number of students enrolled in the third and fourth years of the course at Kimberley are given in Table I. This table was drawn up on the basis of Orr's publication.

Because of the Anglo-Boer War, the number of new

Figure 1—The School of Mines, Hull Street, Kimberley

entrants from 1899 to 1902 and the number of students progressing from the third to the fourth year of study are not clear from the source, and therefore may not be accurate. Nevertheless, one can see from the table that, despite the need and expectations, student enrolment was at a relatively low level right through the life of the School.

With the defeat of the Boer Republics and the extension of British rule over the whole of South Africa, the political incentive to maintain the School of Mines at Kimberley vanished. Owing to the difficulties under which the School was operating, and the fervent wish of Johannesburg to establish a system of technical education of its own, the decision was taken, after several meetings of appropriate representative bodies in 1902 and 1903, to transfer the School to Johannesburg. Although this decision was not free from political influence, the School was to be located, at last, in the centre of a thriving mining area, where its future existence was ensured. Thus, at the end of 1903, 12 third-year and 24 fourth-year students, 1 staff member, and all the equipment were transferred to the newly formed Transvaal Technical Institute in Johannesburg.

Table I

Students enrolled in the third and fourth years of study at the School of Mines, Kimberley

Year of study	Aug 1896	Aug 1897	Aug 1898	Aug 1899	Jul 1900	Jul 1901	Feb 1902	Feb 1903
3	5	13	13	12	24		8	22
4		5	13	14	14	24		8

Despite its short existence, the School of Mines at Kimberley played an important role in the development of South African higher education. With the establishment of the School, the education and training of mining engineers began and, in the wider sense, the development of technical education was stimulated on the sub-continent. It created an acceptable framework for study and education, elements of which can be recognized even in the present-day curriculum. The School produced some fifty engineers, who later became well-respected leaders of the South African mining industry.

On the negative side, the School was affected by a shortage of funds, students, and teaching facilities. The division of the teaching and training effort among the South African College in Cape Town, the School of Mines in Kimberley, and the mines on the Rand was believed to be part of the School's shortcomings. By present-day standards, a further negative aspect of the School's activities was the placing of too much emphasis on practical training, especially during the third year of study.

The Pre-Wits Years

The transfer of the School of Mines from Kimberley to Johannesburg triggered off a long and fierce struggle to elevate the standard of the School and to expand its activities to the level of a teaching university. The period of struggle ended with the inauguration of the University of the Witwatersrand in 1922. As the birth and demise of the School of Mines at Kimberley were influenced to a significant extent by the prevailing political and economic forces, the establishment of the University of the Witwatersrand

was also affected by similar, but more diverse and intense, forces.

The period under review began with the conclusion of the Anglo-Boer War and ended with the Rand revolt. Having signed the Treaty of Vereeniging in 1902, both the British and the Afrikaner leaders formulated their own political objectives. While British politics were motivated by imperial ambitions, the aims of Afrikaner politics were to win the peace and to re-establish self-governments for the Transvaal and Orange River Colonies. With the Liberal government coming into power in Britain in 1905, the zest for meeting Afrikaner political objectives gained momentum, and resulted in the award of responsible governments to the two new Colonies and, eventually, in the formation of the Union of South Africa in 1910. The First World War, the emergence of organized labour, and the sowing of the seeds of apartheid were the factors that characterized the politics for the rest of this period.

The increase in gold production and the rapid expansion of the economy had a positive influence on the recovery of the devastated country shortly after the Anglo-Boer War. Similar improvements in the economy were brought about by the recovery after the 1906–09 depression and the brief economic expansion after the conclusion of the First World War. In addition to these economic events, the importation of Chinese workers, various strikes, and the exclusion of Blacks from most skilled categories of work were features of the turbulent economic history of the period under discussion.

The names of the successive institutions operating in this transitional period reflect the fluctuating levels of success achieved in reaching the ultimate aim of establishing a university in Johannesburg. The Transvaal Technical Institute, which was in existence from 1904 to 1906, provided mainly technical instruction. In order to facilitate the transfer to university status, courses were begun in arts and sciences, and the name of the Institute was changed, in 1906, to Transvaal University College. When, in 1910, Jan Smuts ignored the desire of Johannesburg to promote the Transvaal University College to university status and was instrumental in transferring the teaching of the arts and pure sciences and the Transvaal University College itself to Pretoria, the part of the College that was left in Johannesburg was given the name South African School of Mines and Technology. Because of the perseverance of Johannesburg, the Union Parliament granted powers to the School of Mines, in 1916, to organize courses in arts and pure sciences again and, in recognition of the rapid expansion which took place in the following years, the new title, University College, Johannesburg, was approved in 1920. It was not long after, in 1921, when the establishment of the University of the Witwatersrand was ratified by Parliament.

As can be seen, while the teaching of the arts and pure sciences by the various institutes in this period vacillated, the provision of mining and engineering instruction was continuous and undergoing steady consolidation. One of the reasons for this favourable state of affairs was that both the Engineering and the Mining Departments were set up very early in the life of the Transvaal Technical Institute. Consequently, with the existence of the organizational framework and programme of study, the conditions for the development of higher mining education were established.

Soon after its formation, the Transvaal Technical Institute wanted to be as independent as was possible from both the South African College and the University of the Cape of Good Hope. To this end, the initial plan was to offer a three-year programme in general engineering, to be followed by an additional year of study in which students could specialize in mining and metallurgy or mechanical, electrical, or civil engineering. Furthermore, the Institute decided to examine all its courses and award its own diplomas. Nevertheless, any student who wished to obtain a degree was allowed to sit the examinations set by the University of the Cape of Good Hope.

Despite the suggestion outlined above, the programme of study in mining remained substantially the same during this period as that formulated in Kimberley: two years of science and basic engineering studies, and two years of specialization in mining and metallurgy. As intended, all the courses were provided by the appropriate institutes. The duration of practical training on the mines was reduced considerably, being restricted to the summer vacations. In addition to the full-time study programme, evening classes were also offered and, in 1908, the Senate of the Transvaal University College approved the establishment of a sandwich system of study, which consisted of alternating periods of six months' work in industry and six months' study at the College. This latter system was introduced mainly to overcome the shortage of full-time students brought about by the 1906–09 economic depression.

Initially, accommodation for the Transvaal Technical Institute was primitive, consisting of temporary premises in an old cigar factory and in the Lost Properties building, where the Engineering and Mining Departments were located. To improve the situation, a group of temporary wood-and-iron buildings, known as the Tin Temple, were erected in Plein Square and were occupied early in 1905. Accommodation improved considerably when, in 1909, the first of the Transvaal University College buildings, as shown in Figure 2, was completed on the Eloff Street end of Plein Square. This building housed most of the academic activities of the various institutes, including the University of the Witwatersrand, until 1926, when it was taken over by the Witwatersrand Technical College. The rest of the buildings planned for the Transvaal University College were never completed.

The availability of financial resources, or the lack of them, influenced both the student numbers and the quality of mining instruction provided by the various institutes. In the early days, almost all the finances were directed towards the acquisition of buildings, teaching facilities, and employment of academic and administrative staff. No finances were made available to assist students in the form of bursaries, scholarships, and student amenities. The general funding by the Transvaal Government, the Council of Education, and the mining houses was at a low level, especially during the 1906–09 economic recession. Because of this lack of finance and the recession in general, there was a dramatic reduction of student enrolment in this period. The situation changed favourably during the ensuing economic recovery.

As far as the mining students were concerned, the improvements emanated partly from the establishment of a

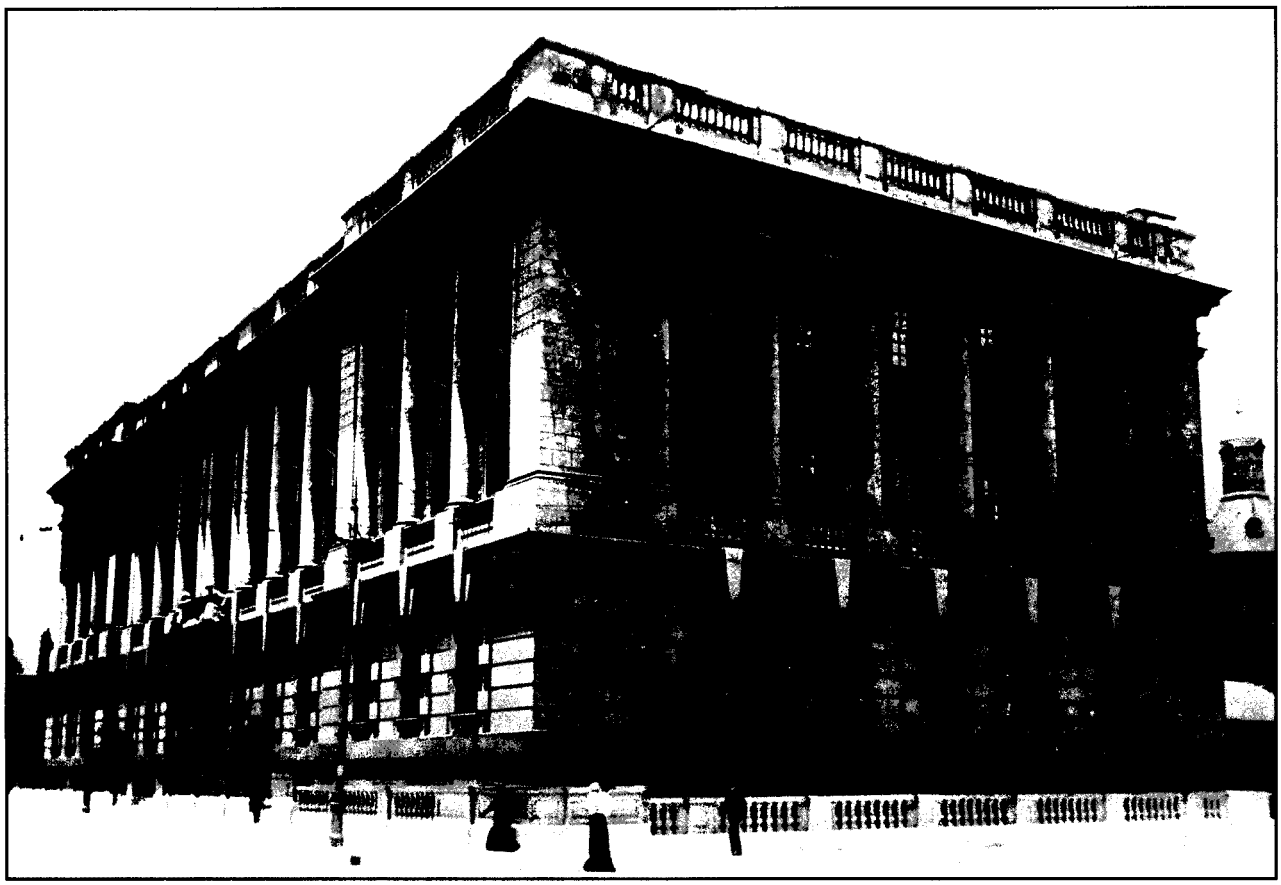

Figure 2—The Transvaal University College, 1909

number of major scholarships. The Hennen Jennings, Barnato, and Neumann scholarships were intended to assist full-time students and were awarded on the results of first-year examinations, while the Rand Mines, Consolidated Goldfields, and E.R.P.M. scholarships were available to selected students taking evening classes to enable them to transfer to day courses. Another particularly important scholarship established in this period was that of the Chamber of Mines for post-diploma research work. Unfortunately the recovery in student numbers was halted by the First World War until the resurgence of economic activities after the War. However, the level of enrolment in mining remained low for the remainder of this period.

As indicated, student numbers were also affected by the participation of students in the War. The level of this participation can be gauged from the following statement by Orr[1]. 'The Great War seriously interfered with the educational work at this time; so many of the engineering students joined the forces that for nearly two years there were practically no third- or fourth-year students in attendance and no mechanical and electrical students for over a year in the fourth-year course'.

Although, in the early part of this period, a number of individuals had been appointed as professors of mining, only a few were directly involved in mining education. The reason for this incongruity was that, until 1912, the professor of mining was also the principal of the appropriate institution. Consequently, several persons were appointed to the position for their administrative abilities, and not necessarily for their mining expertise. Those who participated in mining instruction were Professors T.E. Robertson, J. Yates, G.R. Thompson, and J.S. Cellier. Professor Cellier was a product of the School of Mines in Kimberley, and was the first South African mining graduate to hold the Chair of Mining.

From the points of view of mining education, the period under review had some positive features. The provision of an organizational framework of a department of higher learning and the establishment of a complete programme of mining instruction led to the consolidation and further development of tertiary mining education in this period. The establishment of major scholarships for pre- and post-diploma studies and the foundation of many facets of student life on campus were all part of the continuous development of mining education. The main negative aspects of the activities of the Department of Mining were the low student enrolment and, initially, poor resources. In many respects, the period can be characterized as transitional, but it was an essential period in the evolution of tertiary mining education in South Africa.

The First Three Decades under Wits Administration

In historical terms, the birth of the University of the Witwatersrand, Johannesburg, in 1922 coincided with the White miners' strike, culminating in the Rand revolt and its

subsequent suppression by government forces. The period under review began with this act and ended with the National Party winning complete political power in 1948 and, in the early 1950s, introducing laws that served to underpin its policies of total racial segregation. In the intervening years, both the cause of Afrikaner nationalism and the National Party grew in strength, despite occasional setbacks. The Second World War in this period was also a cataclysmic event that affected the lives of many South Africans, among them some of the students in the Department.

The most important factors that influenced the economy of South Africa in this period were the Great Depression and the subsequent suspension of the Gold Standard in 1932. On the positive side, the gold-mining industry, in particular, benefited from the sharp rise in the gold price. This resulted in one of the greatest expansions of the industry in this century. This consisted of the developent of 15 new mines on the East Rand and the location of a new mine on the Far West Rand, hence opening up one of the richest goldfields in South Africa. After the war, large-scale exploration resulted in the completion of the development of the Far West Rand and the opening up of the Orange Free State goldfield, thus establishing a secure future for the gold-mining industry well into the 21st century.

The inauguration of the University was in some respects not a positive step for the Mining Department. The transition from the Kimberley School of Mines to the University of the Witwatersrand represented a gradual loss of autonomy and importance to the Department. From a major role-player in the affairs of the various institutions, it became virtually the smallest department of the Faculty of Engineering, which was established soon after the University was inaugurated. The very low numbers of students and staff in the Department, and the contraction of the gold-mining industry during the early years of this period, contributed to the despondency and lent uncertainty to the future of mining education in South Africa. It took many years of hard work, the intervention of the mining industry, and changing historical circumstances to propel the Department eventually onto a positive development path.

Figure 3 depicts the number of graduates produced by the Department since 1922. The first portion of this illustration reflects the fluctuating fortunes of the Department associated with student numbers during the period under discussion. It can be seen that, until 1927, the Mining Department at Wits graduated only a small number of mining engineers. It was believed that there were many reasons for the low figure.

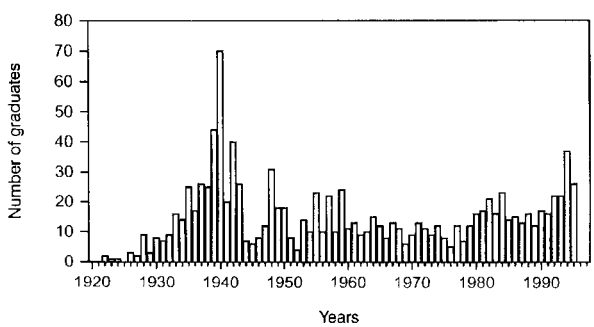

Figure 3—The number of mining graduates from 1922

Murray[2] recorded some of the most important ones. These included a lack of job and promotion prospects in the contracting gold-mining industry, the far-too-theoretical course content, and the unnecessarily high standard that was required from students in the examinations, especially in the mathematical subjects. In order to correct the situation, both the Department and the mining industry contributed to the solution of the problem.

Representatives of the mining industry took part in the work of a joint committee, set up by the University, to scrutinize the standard and programme of study. For its part, the Department had already, in 1924, changed the structure of its mining programme. The change involved sending the final-year students out to work in the mines from Monday to Thursday, and arranging academic instruction to take place on Friday and Saturday. One of the major recommendations of the joint committee was that this system of instruction brought the theoretical and practical work into closer contact and should therefore be continued.

Owing partly to the recommendations of the joint committee, and partly to the abandonment of the Gold Standard in 1932 and the subsequent expansion of the mining industry, the number of graduates in mining increased, as Figure 3 reflects, and remained at a relatively high level until 1943. The largest number of graduates ever produced in a year was 70 in 1940, when many third-year students were permitted to write their third- and fourth-year examinations simultaneously before joining the armed forces. In the last year of the war and in the immediate post-war years, there was a substantial drop in the number of graduates, except in 1948 as returned servicemen completed a shortened degree. Although the number of graduates improved periodically, it remained at a relatively low average figure for many years.

The system in the final year of study of combining practical work on the mines with academic instruction at the University was retained, in various forms, until the early 1940s. Since then, mining students have obtained their compulsory practical training during the summer vacations after the first, second, and third years of study. Until 1942, the degree that was awarded to the graduands of the Department was for a combination of mining and metallurgy. Before that year, students in their final year could specialize either in mining or metallurgy. From 1942, the programme of study offered by the Department led to the award of a degree in mining engineering only. It should be noted that the figures plotted in Figure 3, until 1942 represent the number of graduates in the combined disciplines specified above.

Another change took place in the mining curriculum in 1958 with the introduction of the two specialist options. According to this specialization, students in the final year could choose either the coal- or the gold-mining option of study, giving rise to the award of the Collieries or the Metalliferous sub-divisions of the Mining Engineering Degree, respectively. Initially a number of students took the coal option, but this number soon dropped to a level that made the running of the Colliery option unacceptable, and consequently it was abandoned in the mid 1960s.

The physical location of the Department also changed during this period since the engineering departments had

remained in the Plein Square premises until the Engineering Block at Milner Park was ready for occupation in 1926. The Mining Department was housed in that building until 1941, when it was transferred to the new Hillman Building. No space was acquired by the Department to set up a laboratory to facilitate laboratory practicals in mining subjects either in the Engineering Block or in the Hillman Building.

As indicated earlier, the number of staff involved in the teaching of mining subjects was small during this period. For more than a decade, the staff consisted of a professor and a senior lecturer. In 1939, despite the substantial increase in student numbers up to that year, the staff numbered only three. The Professor of Mining and Surveying, who headed the Department during the early years of Wits, was appointed in 1921. He was G. A. Watermeyer and served the University as Professor of Mining until 1934. His successor was C. Biccard Jeppe, who held the chair until his retirement in 1954. The most notable contributions to mining education of these incumbents of the Chair of Mining were their respective textbooks[3,4].

Before the war years, the leadership of the South African mining industry was largely in the hands of mining graduates from overseas universities. By the early 1940s, there were sufficient Wits graduates working in the industry to take over its technical command. Many mining graduates from this period had distinguished careers, and rose to the highest positions in the mining industry. It would be difficult to list all of them in this paper, but two who achieved great eminence, both as mining men and as citizens of South Africa, should be mentioned.

The first was F. G. (Pinkie) Hill, who graduated in 1927. After completing his studies at Oxford as a Rhodes Scholar, he joined Rand Mines and served the Corner House Group in a variety of technical positions until 1969. His industrious life has been described by Lang[5]. F.G. Hill's interests and activities extended well beyond his technical duties and, with his humanitarian approach to management, he set new standards in labour relations. His achievements were acknowledged by many professional bodies and two universities by the award of various prestigious medals and two honorary doctorates. In his retirement, F. G. Hill also served the University, first as a member then later on as the Chairman of its Council.

The second outstanding individual is D. G. Krige. After graduating in 1938, he worked for Rand Leases Gold Mine, the Department of Mines, and Anglovaal Ltd. During the early years of his retirement, he also held the chair of Mineral Economics in the Department. Most of his professional activities have been associated with ore-reserve calculations, geostatistical research, and mine economics, and his research investigations in geostatistics led to the method of kriging, which is accepted and used world-wide. In recognition of his contributions to the development of geostatistics, he was awarded a D.Sc. by Wits and honorary doctorates by the Universities of Pretoria and South Africa. In addition, he has received numerous gold medals and special awards from professional bodies in South Africa and overseas.

The Department is proud to list both Pinkie Hill and Danie Krige among its most eminent graduates.

As in the First World War, students of the University, including a number of mining students, joined the armed forces in the Second World War. Records show that a total of 1140 Wits students interrupted their studies to take part in the War. In 1970, the University established a Roll of Honour recording the names of members of staff, graduates, and students who gave their lives in the two World Wars and the Korean War. Unfortunately, the records do not indicate the home department of the students who served or lost their lives in the Second World War.

In some respects, this period of the Department's history was positive, in others it lacked historical significance. In one decade of this period, 1933 to 1943, the number of students who successfully completed their studies was much higher than any other decade between 1896 and 1996. The quality of some of the graduates was also outstandingly high. However, perhaps owing to a lack of leadership, these and other positive factors were not utilized to build up the Department by increasing the staff and establishing a mining laboratory. It was also unfortunate that the genuine transition from the old School of Mines to a true university department was not given sufficient impetus in this period.

Decades of Steady Progress

The period from the mid 1950s to the early 1980s was characterized by the two opposing political objectives and actions of the major role-players in South Africa. On one hand, the ruling National Party pursued its separate-development policies with new determination. As a result, hundreds of thousands of non-Whites were relocated, and the homelands were turned into national states. On the other hand, the killing of 69 people protesting against the pass laws at Sharpeville provoked the liberation movements to abandon non-violent protest and opt for armed insurgency. The liberation of Zimbabwe and the Portuguese colonies of Mozambique and Angola changed the balance of political power in the region in favour of the emerging Black nations and the liberation movements in South Africa. The Soweto rebellion on 16th June, 1976, which, within a short time, took on countrywide proportions, had far-reaching repercussions and represented a turning point in the most recent history of South Africa.

By the mid 1950s, most of the gold mines that had opened up during the large-scale expansion in the pre- and post-war periods were in operation. This was also the time when the problems associated with the large extent of worked-out areas and the increased depth of the workings began to take on serious proportions. The increasing number of rockbursts and the deteriorating environmental conditions in the workplace were the most noticeable problems experienced by the gold-mining industry. The coal-mining industry also had its share of difficulties, of which uncertainty about the safe level of extraction of a coal seam was the most serious. Unfortunately, this lack of expertise eventually resulted in a serious accident at Coalbrook in 1960, which claimed the lives of 437 men.

To overcome the technical problems in the mining industry, increasingly greater amounts of effort were expended on research into a variety of mining-related fields. Consequently, from the beginning of the period and with the passage of time, more and more research results became

available that had to be incorporated in the teaching material. It was also a period when the Department had the opportunity to participate in the accelerating research programme. Both the availability of advanced knowledge and the departmental research work gave rise to the establishment of post-graduate courses and corresponding academic qualifications.

The progressive outlook in the teaching of mining-engineering subjects and the initiation of research activities justified the Department's claim for more appropriate housing. Thus, in 1961, part of the new Geology Building was made available to the Department, where the standard of both the staff accommodation and the lecturing facilities was much improved, and the establishment of a mining laboratory and workshop could begin. By the end of the period, the Department had a first-rate workshop and several well-equipped laboratories. Unfortunately, the lack of space in the Geology building restricted the further development and, later on, the modernization of these laboratories.

The accumulation of contemporary knowledge in mining engineering was mainly associated with developments in rock mechanics, mine valuation, environmental engineering, and the use of explosives. In addition, the application of electronic computers in engineering and education was also gathering momentum. To take cognizance of these advances, the undergraduate programme was modified several times during this period. In the early 1960s, the first two years of the mining-engineering programme was the same as those of the other engineering students in the faculty, and the teaching of professional subjects was restricted to the last two years of study[6]. The mining programme two decades later reflects that several courses in the second year were replaced by mining and related subjects, retaining only the first year as common with the other engineering departments.

The publication by Plewman and King[7] shows that both the subjects taught and their contents in the senior undergraduate years also underwent considerable changes. By the early 1970s, rock mechanics was well and truly entrenched in the mining programme, covering both the essential theoretical and practical aspects of the discipline. The importance of this aspect of the mining degree was recognized in 1974, when the University created a Chair of Rock Mechanics. The new material on the study and control of the working environment was incorporated in the old mine-ventilation subject and given a new name: environmental engineering. The teaching of mining economics was increased in scope, eventually resulting in four courses. The relatively new study of geostatistics, which gave a scientific basis to mine valuation, was one of the four courses. The introduction of a subject covering surface-mining methods and a new approach to the use of explosives completed the re-structuring of the mining programme at Wits to the extent that it was possible at the end of this period.

Despite the accelerated expansion of the mining industry, mentioned earlier, and the corresponding improvements in job and career prospects, the enrolment in mining engineering, and consequently the number of graduating students, remained relatively low. There were years in which the enrolment was high, but the failure rate in the first two years of study was so high that only 40 per cent reached the final, graduating year. It is believed that the major reasons for these phenomena were the general drift of prospective students to the more fashionable branches of engineering, and the establishment of a new mining department at Pretoria University in the early 1960s. Furthermore, at the beginning of this period, it was general practice that students sponsored by the mining groups spent one or more years on underground training as learner officials before being sent to university to study for their degrees. Unfortunately for some students, this break was too protracted and adversely affected both their attitude to study and their performance in the academic subjects. The system was therefore discontinued, and the bursary scheme was modified. Despite the availability of generous bursaries, school-leavers did not favour mining engineering as a career, and the number of graduates produced by the Department remained relatively low until the early 1980s.

Although the more recent graduates from this period have still to make their mark in the mining industry, some earlier graduates have already achieved prominence in leading the industry in a variety of senior positions. One can record with pride that, from this group, 10 have risen to the pinnacle of success in mining houses, 4 have served as president of the Chamber of Mines and 3 have elected to serve the industry as professors of mining engineering. It should also be recorded that 2 graduates were selected to complete their studies as Rhodes Scholars.

Although 13 M.Sc. degrees were awarded by the University for research work in mining engineering in the period 1922 to 1955, the option of obtaining an M.Sc. by a combination of course work and a limited research project was introduced only in 1961. In that year, the Department offered three technical postgraduate courses and five courses in the fields of mine management and economics. The latter courses were intended for men with some years of practical experience. By 1982, the number of courses on offer grew to 25 but, owing to limitations imposed by staff numbers, no more than 6 could be run in any one year. Postgraduate students could also obtain the qualification of Graduate Diploma in Engineering by successfully completing the required number of courses without the research project. Towards the end of the period, some 15 to 20 students attended these courses annually. University statistics show that, between 1955 and 1982, 10 Ph.D. degrees, 40 M.Sc. degrees, and 31 Graduate Diplomas were awarded for mining-related postgraduate studies and research.

Research became a part of the Department's activity not only to satisfy the requirements for the award of higher degrees, but also to utilize its resources. To give a framework to the various research activities, a Research Unit was established in 1961 and remained in operation until 1982. Most of the finances to maintain the Research Unit came from the Chamber of Mines. The fields in which the Department contributed to the ongoing research effort were: rock mechanics, rock fragmentation by explosives, and environmental engineering.

The number and composition of the academic staff also reflected the steady growth of the Department. In 1961 the staff consisted of 1 Professor, 3 Senior Lecturers and, in the Research Unit, 2 Senior and 2 Junior Research Fellows. The corresponding numbers in 1982 were: 3 Professors, 4 Senior

Lecturers and 1 Senior Research Fellow. The two specialized professorships were established in the fields of rock mechanics and mineral economics respectively, with the chair of Rock Mechanics being held from 1974 to 1991 by Professor S. Budavari and the personal chair of Mineral Economics by Professor D.G. Krige from 1981 to 1991. During this period the Department was headed by Professors R. A. L. Black, from 1955 to 1962, and R. P. Plewman, from 1963 to 1982.

The preceding paragraphs in this section reveal that the Department's activities underwent fundamental changes in this period. From a purely teaching institution, it became a progressive university department, which incorporated relevant, modern technical knowledge into its curricula and extended its activities into postgraduate studies and research. It established and equipped several laboratories and introduced laboratory practicals to complement the classroom instruction. The increase of academic staff and the establishment of research positions and the two specialized chairs also reflect the steady growth of the Department. It is believed that the shortcoming of this period was that the high failure rate in the junior years was not addressed with sufficient vigour.

The Period of Transition to Multiracial Education

The Soweto unrest and its aftermath caused deep economic depression, industrial strife, flight of foreign capital, broadening international isolation, and a rising tide of Black opposition. All these factors contributed to the accelerated decline of White rule, thus bringing about the conditions for inevitable political changes. Eventually, the De Klerk government accepted the failure of apartheid and the need for transformation. The political changes and the accompanying restructuring of South African society characterized this last period under review.

The liberal spirit that dominated the policies of Wits since the beginning of the apartheid era inevitably influenced the Department of Mining Engineering in carrying out its duties. For decades, the Department had advocated the extension of its educational activities to all students irrespective of colour[6,7]. Despite these efforts, the gradual recruitment of non-White students to the mining-engineering programme began only in the 1980s, when political conditions permitted it. This change was made possible by the weakening of the apartheid system of government and the consequent repeal of the relevant legislation in 1983.

As a result of the fundamental transformation of South African society, the Wits student population in mining engineering has gradually become multiracial, as shown in Figure 4. While this was to be expected and was indeed welcomed by the Department, the problems associated with the teaching of classes containing a considerable number of under-prepared junior students, especially those from disadvantaged educational backgrounds, have caused increasing concern. This prompted the Department to review its responsibilities and the objectives and methods of the education it provided. This critical review, with the aim of providing a modern and more effective mining education, has dominated the activities of the Department in recent times. The main aspects of the review are briefly described in the following paragraphs.

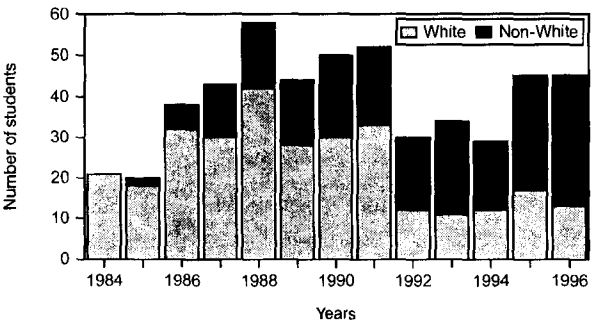

Figure 4—New enrolments in first year, 1984–96

As generally accepted, the activities of university engineering departments are governed by their responsibilities as determined by society, various industries, and the appropriate professional bodies. Among their main responsibilities is that of promoting engineering sciences through education and research.

At undergraduate level, the objectives of engineering education are the acquisition of knowledge and the development of certain abilities and attitudes. Knowledge, in this context, includes basic engineering science and its application, current practice in the relevant engineering branch, economic considerations, safety requirements, and the principles of management. The various engineering courses are required to assist students in the development of abilities to obtain and manage information efficiently, to think clearly, to make decisions, to be creative, and to communicate effectively. University education should also provide the engineering student with a certain degree of professionalism, and a responsible attitude towards his work and society. In order to keep up with the rapid advances in technology and in discipline-related knowledge, students of engineering should be taught to accept progress and to develop a habit of learning.

For postgraduates, the objectives of university engineering departments are to enable students to acquire knowledge, in some selected field, to a greater depth, and to gain experience in scientific research. Postgraduate courses should present the most up-to-date practice and give examples of its application in an appropriate industrial environment. Research carried out in a university department is an essential activity, and is a combined effort by postgraduate students and staff. One of the distinguishing factors between the old mining schools and a university department is that the latter, in addition to fulfilling its educational obligations, promotes postgraduate studies and research, thus taking part in advancing the frontiers of knowledge.

The Department of Mining Engineering is committed to the philosophy set out above, which is in agreement with the aims and objectives of professional bodies both here (SACPE document No. 15/1/4) and overseas. The curriculum, the material taught, the method of teaching, the industrial training, and the close liaison with industry are all designed to facilitate the education of students to the highest international standard.

The present undergraduate programme at Wits, which is of four years' duration and leads to the degree of Bachelor of

Science in Engineering, educates the student to enter any sector of the mining industry. The first year of study is devoted to the basic sciences in order to supplement the broadly based matriculation obtained at the end of 12 years of schooling. Thereafter, the successive years of study involve engineering sciences, mining sciences, and professional mining subjects. The curriculum for the mining degree is shown in Figure 5.

In a review of the Department's activities, the curricula at 32 university mining departments in 23 countries were studied and compared with the mining programme at Wits. It was concluded that, with minor variations, the Wits curriculum was similar to those of the overseas institutions and that, apart from the fact that the Wits curriculum contained more rock mechanics, more reserve valuation or geostatistics, more financial management, and less liberal and environmental studies than some of the courses overseas, it was well balanced and directed to serve the South African mining industry.

The Department also investigated the educational achievements of its intake, the efficiency of its teaching, and the receptiveness of the students involved in the educational process. This was particularly relevant in view of the diverse backgrounds of the current student population. In this respect, the cumulative experience of the Division of Engineering Support Programmes in the Faculty of Engineering was utilized to provide an appreciation of the problems.

In the survey of the educational standard reached by scholars entering university, the main requirements to become successful engineering students were identified as follows: a degree of innate intelligence, a level of knowledge in mathematics and physical sciences, an acceptable level of communication capability in the medium of instruction, the essential abilities and skills for learning, and a high degree of motivation. It is generally accepted that, apart from innate intelligence, most of these attributes can be improved and brought up to the required standard by remedial education and the use of bridging programmes.

An analysis of the performance of first-year mining students indicated that many of them were poorly prepared to undertake engineering studies. Their shortcomings were attributed to a low level of knowledge in mathematics and physical sciences, communication deficiencies, and lack of essential abilities and skills for learning. Further problems experienced were the difficult transition from high-school to university studies, difficulties in absorbing the study material at the rate it is presented, and lack of personal development to meet the needs of modern society. The analysis also yielded a number of conclusions that called for a series of actions to be taken by the Department if it wanted to ensure that the standard of its graduates was not impaired irrespective of the educational achievements of the intake.

In order to deal with the poor preparedness of students and to assist in their studies in the first and second years, the Department accepted the need for bridging courses, remedial teaching, and the small-group tutorial system. During the past decade, several bridging programmes have been established to offer Black matriculants who have the potential to succeed either a one-year programme of academic and engineering studies before enrolment in first year, or a two-year programme to enable successful students to obtain credit for the first year of study. These bridging

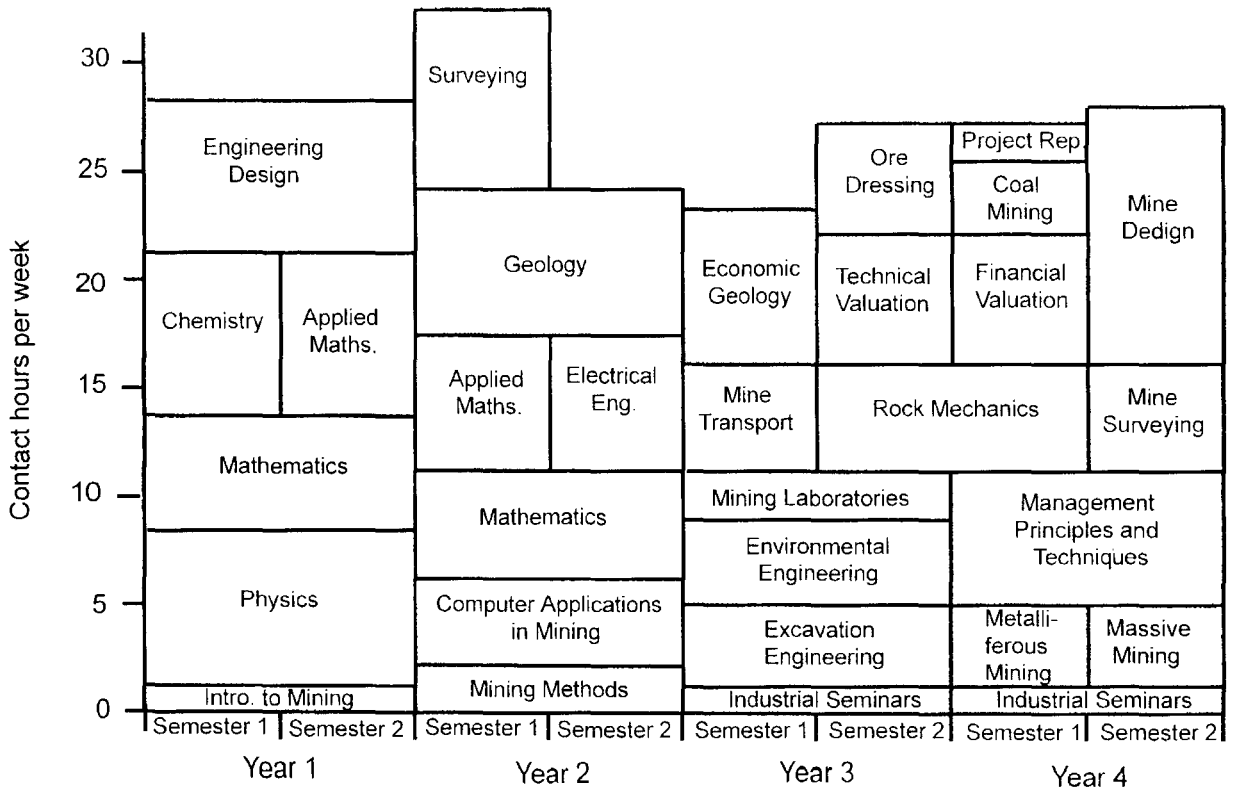

Figure 5—Mining-engineering curriculum

Figure 3 - Mining engineering curriculum

programmes are run by the Division of Engineering Support Programmes and the College of Science. The small-group tutorials and supplemental instruction schemes were introduced to assist selected students in their first and second years by providing them with increased contact with tutors and group-learning sessions in some subjects.

As far as the third- and fourth-year students were concerned, the Department recognized that more conscious effort had to be expended to improve the development of abilities and attitudes, especially problem-solving capabilities. To this end, students are more actively involved in the educational process, and the teaching and learning aspects of student–staff contact time have been made more effective. The staff also suggested and implemented ways and means by which the theory and practice could be balanced in the various courses, and both the confidence and the motivation of the students have increased by measurable degrees.

The structure of the postgraduate studies leading to the award of the Graduate Diploma in Engineering (G.D.E.), M.Sc. and Ph.D. remained substantially the same as was established in the 1950–80 period. The one modification that has been made allows students after successfully completing 12 G.D.E. courses, to obtain an M.Sc. degree by coursework alone in the specialized fields of mineral economics and rock mechanics. To cater for the high demand in general, and to allow students to complete the 12 courses within a reasonable period, the Department increased the number of G.D.E. courses on offer to 16 or 17 each year. Departmental records indicate that there has been a significant expansion in postgraduate activities over the past decade. Figure 6 depicts the postgraduate registration since 1984. The plotted data reflect an equal growth in demand for continuing education through coursework and for research-based degrees.

The late 1980s was a period of considerable change for the Department, involving a growth not only in student and staff numbers, but also in its physical location. In 1985, the University acquired the agricultural showgrounds adjacent to the existing campus, and started the development of the West Campus. On completion of the new Chamber of Mines Engineering Building on the West Campus in 1989, the Department moved into new premises, and the current home of the Department is shown in Figure 7. Staff accommodation and lecturing facilities were provided in this building, while the laboratories and the workshop were transferred to the adjacent Genmin Laboratories Building. The overall laboratory space was adequate to increase the sizes of the

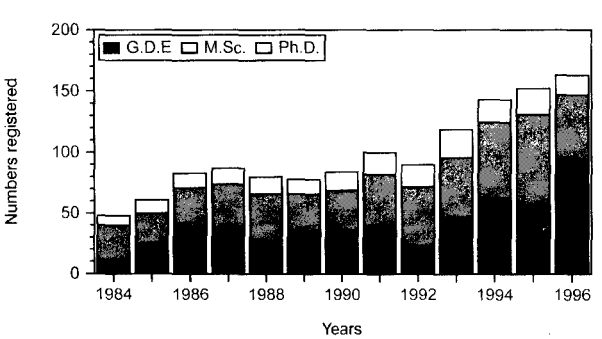

Figure 6—Post-graduate registrations since 1984

old laboratories and to create accommodation for postgraduate students and for several new laboratories. The move to the West Campus provided the Department with the stimulus to re-equip in certain areas, and there are now up-to-date laboratories to serve both teaching and research in the following areas: rock mechanics, excavation engineering, mine ventilation and climate control, computing, mine design, and digital photogrammetry.

In the 1980s, the number of students studying for a degree in surveying dropped considerably throughout South Africa. Consequently, an agreement was reached with other universities that, in the foreseeable future, only two universities would provide courses and award degrees in the field of surveying. Having lost the need for providing mainstream courses, the Department of Surveying at Wits merged with the Department of Mining Engineering in 1990. The four staff positions that were transferred to the Department allowed for service teaching in surveying throughout the University, and these staff are also involved in giving specialized courses in mining and surveying at both undergraduate and postgraduate level.

Even before Surveying merged with the Department, the number of academic staff increased gradually. However, with the merger and the appointment of several specialists in certain key areas, the size of the staff doubled in the first years of the 1990s. The new appointments led to the development of additional postgraduate courses and an upturn in departmental involvement in research and postgraduate supervision. The present academic staff consists of 2 professors, 1 associate professor, 7 senior lecturers, 3 lecturers, and 1 junior lecturer; 4 of the positions listed are fully financed by the Chamber of Mines of South Africa, and all the staff salaries are also supplemented by the mining industry. From 1982 to 1985, the Department was headed by Professor Budavari. The Chamber of Mines Chair of Mining Engineering, which fell vacant with the retirement in 1982 of Professor Plewman, was filled in 1985 by the appointment of Professor H.R. Phillips, who has also been head of the Department since 1986.

During this period, a great deal of effort has been expended in the modernization of the undergraduate syllabus, in improving the performance of students, and in the development of additional postgraduate courses and research. Some of the efforts have already borne fruit, but a number of educational objectives are of long-term duration, and their outcome cannot yet be evaluated. In addition, the period under review is a short one in comparison with the earlier periods. For these reasons, it would not be appropriate to discuss the Department's performance in this period in historical terms. Nevertheless, as the previous paragraphs indicate, in recent years, the Department, utilizing the accomplishments of preceding periods, has considerably improved its educational facilities and capabilities, and increased its number of both undergraduate and postgraduate students.

Concluding Remarks

This short review of past and present educational activities of the various institutions, from the South African School of Mines to the Department of Mining Engineering at

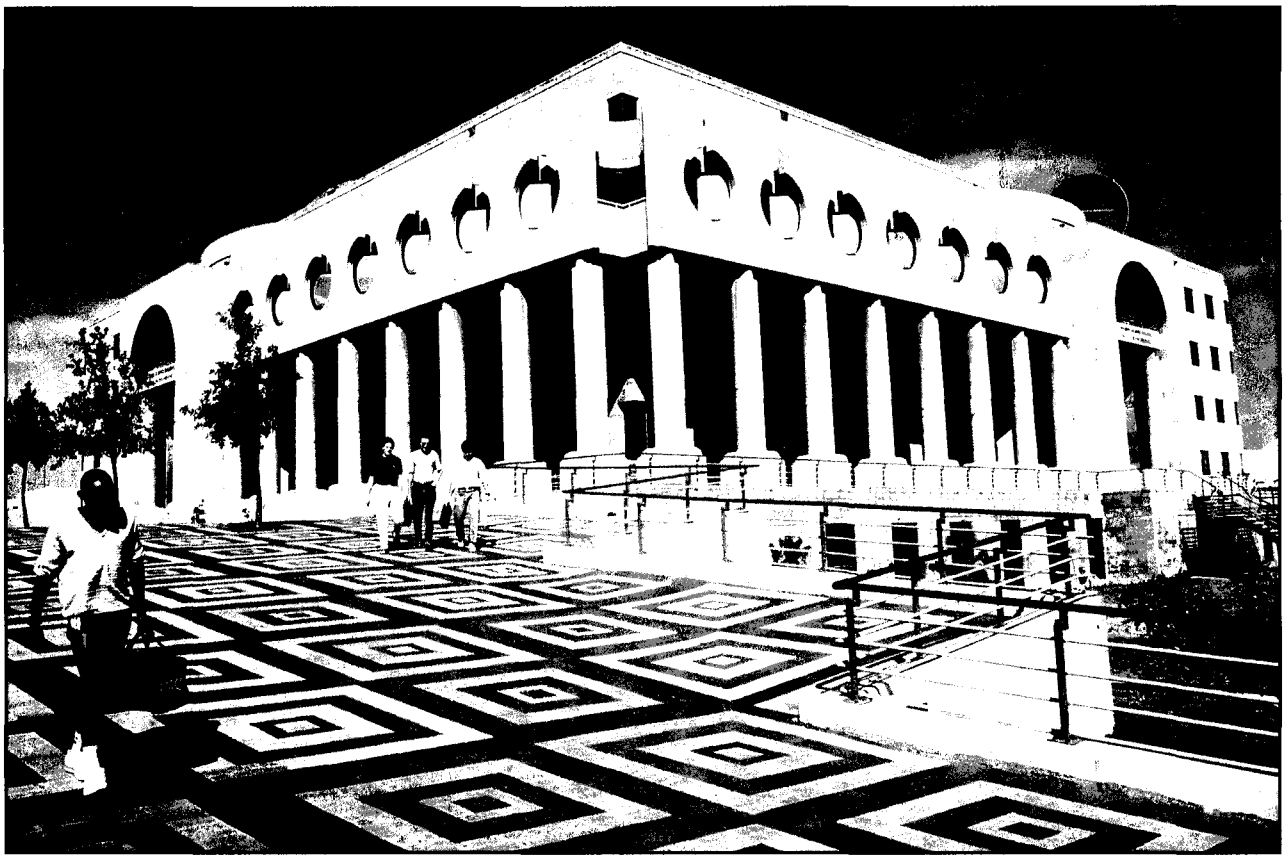

Figure 7—The Chamber of Mines Engineering Building, 1989

the University of the Witwatersrand, brings to light a number of important points that need to be recorded. It is appreciated that the formulation of these points and the critical evaluation of the academic activities in the various periods are subjective, and are based on a present-day perspective. The authors also accept that, during the past hundred years, a number of educational practices and objectives directed the work of the mining schools and the Department, and that these practices and objectives were fully sanctioned in the respective periods.

From a historical point of view, the various academic mining institutions played their part in the development of South Africa. Tertiary mining education set the pace of technical education in the country during many decades in this century. Through their activities, the institutions contributed to the development of the mining industry and to the industrialization of the country. The evolution of Wits was also influenced, to some extent, by the existence of a mature Mining Department.

It is obvious from the preceding discussions, that mining education was influenced, from its inauguration to the present day, by both political and economic factors. However, the fortunes of the mining industry had an overriding effect on the provision of this education. Student enrolments and the numbers of graduates produced fluctuated in harmony with the varying degrees of prosperity in the industry. Since the number of students enrolled in mining was generally low, these fluctuations made it even more difficult for the Department to satisfy the needs of the South African mining industry, despite the consistent and generous support, financial and other, it received from the industry.

Following the development of tertiary mining education, one can conclude that the early institutions, and for a number of decades also the Mining Department at Wits, were almost exclusively concerned with technical instruction. Engineering education with wider objectives, as is accepted and practised today, was consciously included in mining academic pursuits only in the 1950s. Since then, the Department's activities have advanced to the level of a modern university engineering department.

Right from the beginning, the primary aim of tertiary mining education has been the transformation of intelligent matriculants into young engineers, ready to be trained as professional mining engineers. This has been carried out through a programme of study that was updated periodically by the incorporation of new developments both in South Africa and in overseas countries. More intense postgraduate teaching and research were included in the academic activities only from the mid 1950s and, owing to their accelerated development, the extent of the Department's involvement has become nearly equal to that of its undergraduate teaching duties. The Department has also met its obligations to the South African mining industry and professional bodies by extending its activities beyond the confines of the University.

The final conclusions one should derive from this paper are associated with the academic accomplishments and the quality of educational activities in which the mining schools and the Department have been involved. As far as the numbers of graduates are concerned, in some periods the relevant institutions did not fare well, but the technical leadership of the South African mining industry, past and present, bears testimony to the quality of the graduates. If one considers the full spectrum of activities, there is no doubt about the high degree of accomplishments, and there is every cause for satisfaction. The achievements are due primarily to the dedicated staff of the various institutions, the energetic student bodies, the caring alumni associations, and the many individuals who, directly or indirectly, contributed to this remarkable educational effort over the past hundred years.

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New appointment

Denis Twigg has been appointed as Professor of the Port Elizabeth Technikon.

With his wife Margaret, two sons, Christopher and Philip, and daughter Jennifer, he emigrated from England to South Africa in 1975. His first position in this country was Lecturer in Materials Science at the University of Port Elizabeth. He then moved on to the Metallurgy Division of the South African Bureau of Standards, Pretoria, where he eventually became the Head of Division. From 1983 to 1990, he was the Executive Director of the Galvanizers Association of Southern Africa. He has held his present position as Head of Department of Materials and Metallurgical Engineering at the Port Elizabeth Technikon for the past six years.

The Port Elizabeth Technikon follows the qualified *ad hominem* approach to professorships. Accordingly, his title was awarded on specific criteria, which included his achievements in his present and previous positions, research, contributions to journals, papers delivered, supervision of postgraduate students, and recognition by industry.

Professor Twigg assists industry in the disciplines of corrosion protection and metal-failure analysis. ◆

SA technology for Chile*

A Mintek team returned recently from Chile, where it scored a double first at the gold-milling plant of El Indio's Tambo mine in the Andes. It was the first time that Mintek's particle-size estimator (PSE) was used outside South Africa, and the first time that this piece of equipment was installed on a cyclone cluster, having been used only on single cyclones in the past.

The PSE is a microprocessor-based instrument that is used in conjunction with a hydrocyclone underflow meter (HUM) to monitor, control, and optimize hydrocycloning and milling circuits. The HUM gives an accurate reading of a hydrocyclone discharge spray by means of a mechanical arm that floats on the discharge stream, the angle of the arm being measured by an electromechanical transducer: the PSE derives a continuous estimate of the particle size in a hydrocyclone-overflow product stream from a heuristic model based on the output of the HUM, as well as on the flowrate of the cyclone feed and density measurements.

The advantages of this technique is that it is simple and robust, and it eliminates the need for the sampling of the product stream. The particle size is displayed numerically, as well as by electrical signal.

The equipment is currently in operation in a number of milling circuits on South African gold mines.

Issued by Mintek, Private Bag X3015, Randburg 2125. ◆