MUSINGWINI, C. Introduction of specialization in Mine Planning and Optimisation within the Master's degree (MSc) programme at the University of Witwatersrand. *The 6th International Platinum Conference, 'Platinum–Metal for the Future'*, The Southern African Institute of Mining and Metallurgy, 2014.

Introduction of specialization in Mine Planning and Optimisation within the Master's degree (MSc) programme at the University of Witwatersrand

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Mine Planning and Optimisation plays a key role in informing the strategic and tactical decision-making processes in mining companies. Despite the importance of this specialization, as of 2013 there were no formal postgraduate qualifications being offered in this area of specialization (AoS) in existing Master of Science (MSc) degree programmes in South Africa. Accordingly, the School of Mining Engineering at the University of the Witwatersrand (Wits Mining) developed this AoS and introduced it into the existing MSc programme in 2014. This paper explains the rationale for, structure of, and process followed in developing this AoS, so that skills in this area can be developed for future use by the South African mining industry.

Introduction

The mining industry can no longer rely on high-grade, shallow orebodies especially for precious metals such as gold and platinum, as such ore-bodies have been almost depleted. Added to this challenge is that existing orebodies for these minerals are generally of lower grades and have to be mined at deeper levels. This trend requires companies to formulate optimized exploitation strategies in order to remain competitive in converting Mineral Resources to Mineral Reserves. For example, the average resource grade of gold mines in South Africa has been in steady decline from approximately 12 g/t in the 1970s to current resource grades of approximately 5 g/t, while average depths of mining steadily increased from approximately 1 km in the 1970s to 4 km currently. Figure 1 shows the recent declining trend in the average recovered grades for South African gold mines. Figure 2 illustrates the decline in average recovered gold grades of ore mined in South Africa, Australia, Canada, Brazil, and the USA between 1830 and 2004. The implication of this general trend is that gold mines now have to move greater tonnages from increased depths of mining, and achieve higher recovery efficiencies, in order to maintain or improve profitability. These challenges are further compounded by increasing production costs and lower productivity associated with increasing mining depths. Mines are thus required to continuously innovate on how they plan and operate their production systems, which requires increased skills in mine planning and optimisation.

Mine Planning and Optimisation plays a key role in informing the strategic and tactical decision-making processes in mining companies when Mineral Resources are converted into Mineral Reserves. Mineral Reserves are

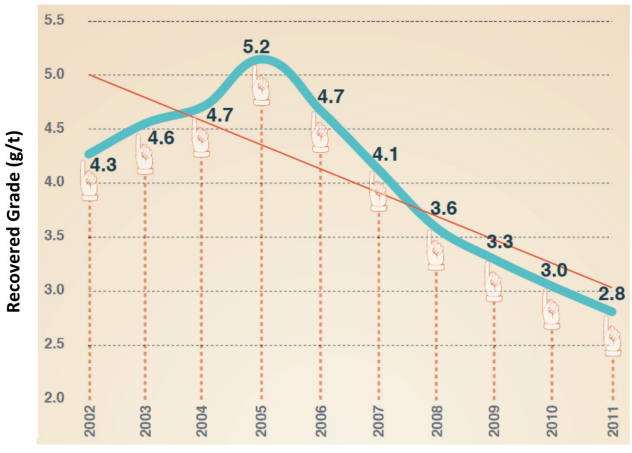

Figure 1. South African average recovered gold grade (vertical axis) against year (horizontal axis) (Source: Chamber of Mines of South Africa, 2012)

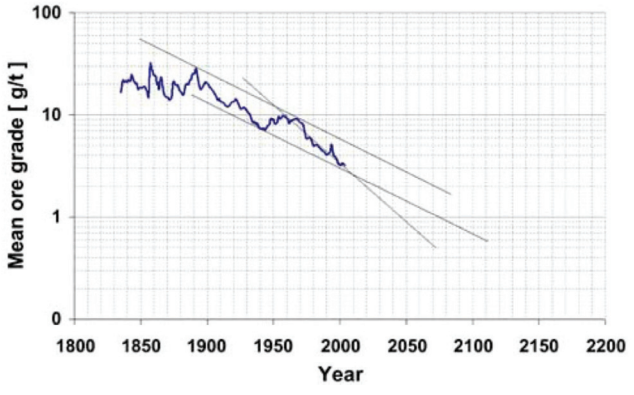

Figure 2. Average recovered grade for gold in South Africa, Australia, Canada, Brazil, and the USA between 1830 and 2004 (Source: Müller and Frimmel, 2010)

the primary asset of any mining company, ensuring not only that a mine can continue to survive, but that it can also thrive into the future. However, as of 2013 there was no formal postgraduate qualification in this area of specialization (AoS) in existing Master of Science (MSc) degree programmes in South Africa. The School of Mining Engineering at the University of the Witwatersrand (Wits Mining) responded to this challenge by developing this AoS and in 2014 successfully introduced it into the existing MSc programme. It is hoped that the introduction of this important AoS will contribute towards developing more skills that will be required to keep the South African mining industry viable in coming decades.

Rationale for introducing Mine Planning and Optimisation

The general structure of undergraduate mining engineering programmes in South Africa does not provide for specialization, as this occurs only at postgraduate level. Several developments that have acted as precursors to trigger the introduction of the Mine Planning and Optimisation AoS at a postgraduate level in South Africa include the following:

- In 2010 Wits Mining held a consultative postgraduate workshop at which industry participants were invited to review the specialization offerings at postgraduate level. The participants proposed that mine planning and optimisation be introduced as an additional AoS into the existing MSc degree programme
- Up to 2013 no university in South Africa was offering a specialization in Mine Planning at MSc degree level, implying that any practitioner or professional in the country wishing to study in this area would have to study abroad unless a similar course was offered locally
- In 2011 Wits Mining introduced a certificate course in Mine Planning. An MSc in Mine Planning and Optimisation would provide a future articulation route for graduates from this certificate course wishing to further their knowledge in mine planning at an advanced level
- Wits Mining has a Mine Planning, Optimisation and Valuation (MPOV) research group undertaking research in the area of mine planning. The introduction of an MSc in Mine Planning and Optimisation creates synergy with this research group
- In 2012 the Industry Mine Planning Forum of the Southern African Institute of Mining and Metallurgy (SAIMM) designed a National Qualifications Framework (NQF) compliant Level 4 Mine Planning and Design qualification. This qualification was submitted for registration with the Mining Qualifications Authority (MQA) following the Quality Council for Trades and Occupations (QCTO) process. An MSc in Mine Planning and Optimisation qualification provides a future articulation route for mine planning graduates completing the Level 4 qualification to further their studies through completing the Level 6 Wits Mining certificate in Mine Planning
- An MSc in Mine Planning and Optimisation generates a pool from which future PhDs in mine planning can be developed to undertake relevant research in this important area
- In 2012 the Institute of Mine Surveyors of South Africa (IMSSA) requested the Engineering Council of South Africa (ECSA) to recognize PLATO-registered Mine Surveyors practising as mine planning professionals. Some of these surveyors may later find merit in pursuing an MSc in Mine Planning and Optimisation
- The Wits Mining MSc programme was already offering some courses which can broadly be classified as mine planning and optimisation courses and which could be incorporated into a proper structure defining a specialization in Mine Planning and Optimisation.

The above cues highlighted a need for the development of a postgraduate qualification in Mine Planning and Optimisation at MSc level. The process followed in establishing the AoS, is described in the next section.

Process for developing area of specialization

It was important to initially set up a Steering Committee to drive the development of the AoS. The committee comprised academics, industry professionals from mining companies, and consultants who are specifically involved in mine planning and optimisation. The AoS was specifically branded as Mine Planning and Optimisation and excluded the design aspect so that applicants would not be under the impression that after graduating they could proceed to register as professional engineers. ECSA provisions, which are consistent with the Washington Accord, enable graduates with first degrees in engineering to register as professional engineers. However, as indicated in the section below, this AoS allows entry of non-engineering applicants.

The committee's first task was to compile a proposal motivating the introduction of the AoS. This proposal outlined the entry requirements to cater for the diverse applicants. It also included a structure that recognized the university's requirements and approval processes. These aspects are described in subsequent sections.

Entry requirements

It was prudent for the Steering Committee to adopt the Wits Mining general admission requirements for the MSc programme as the AoS was being introduced within the existing MSc programme. Postgraduate admission to Wits Mining is governed by the Department of Higher Education and Training policies, which allow Higher Education institutions to set specific admission requirements. Admission is affected by the applicant's previous qualifications, performance in their final year of study, and availability of seats on the programme. The following applicants are eligible to be considered for admission to the MSc in Mine Planning and Optimisation:

- Mining Engineering graduates from the University of Witwatersrand and Honours-level Mining Engineering graduates from other South African universities
- Differently Qualified Applicants (DQAs) with South African or foreign qualifications who have relevant recognized prior learning (RPL). The RPL has to be considered by the School as equivalent to a relevant bachelor's degree to give the DQA applicants access to the programme. Unless there are exceptional circumstances, DQA applicants are required to successfully complete the two-week Introduction to Mining Engineering Topics course offered by Wits Mining before they can be considered for admission to the MSc programme.

It is important to note that any credits earned through RPL only give DQA applicants access to the programme, and cannot be used as credits for the MSc in Mine Planning and Optimisation. Each applicant is considered on merit

and exemption is restricted to a maximum of 50% of the total MSc qualification.

Structure of area of specialization

The MSc in Mine Planning and Optimisation is positioned at Level 9 on the new de-bunched 10-Level Higher Education Qualifications Framework (HEQF), which corresponds to Level 8 on the old 8-Level NQF. The HEQF was the result of the amendment of the Higher Education Act in 2007 and sets out the requirements for Level 5-10 qualifications on the NQF. As noted by Jewison (2008), the old NQF Levels were considered to be too restrictive and did not provide adequate differentiation for postgraduate qualifications, so the extension of the NQF to 10 levels affected mainly levels of postgraduate qualifications. The changes in the NQF Levels are depicted in Table I.

The structure of AoS was designed to align with the new NQF Level 9 descriptors as defined by the South African Qualifications Authority (2012) and broadly provides graduates in mining engineering or mining-related fields with an advanced understanding of the intellectual processes, concepts, methodologies, and tools required for:

- Planning safe and efficient mining operations
- Independently conceptualizing and undertaking relevant and meaningful research inquiry in mine planning problems for mining operations.

These two broad requirements meant that the AoS in Mine Planning and Optimisation had to comprise both coursework and research. The AoS is targeted at graduates or well-experienced practitioners currently working within the mining industry, who wish to upgrade their knowledge in mine planning and optimisation with a view to furthering their careers in this field or related fields such as mineral resource management. The specialisation in Mine Planning and Optimisation is intended to be a 1-year full-time or 2-year part-time course offered as a block-release programme in order to cater for those planning to learn while they continue working. The structure of the curriculum was aligned with the existing 240-credit point Master of Science in Engineering by coursework and a research report (MSc 50/50) in the branch of Mining Engineering. Students are required to complete six 20-credit point courses totalling 120 credit points, and a 120-credit point research report, making a total of 240 credit points. Table II illustrates how students can articulate their way through the programme. It should be noted that a credit point is equivalent to 10 notional hours. A notional hour is the total time spent for face-to-face contact (contact hours) with a lecturer together with the hours a student is expected to spend in undertaking self-study.

The Steering Committee was also cognisant of developments within the higher education framework to phase out 240-credit point MSc degrees by 2016 and have in their place 180-credit point MSc degrees in order to align with international requirements for such qualifications. To cater for this development without compromising on the quality of the qualification, the committee proposed the

Table I
NQF Levels for qualifications

Old NQF Level (pre-2008)	Qualification	New NQF Level of HEQF (post-2008)	Qualification
8	Doctorate degree	10	Doctorate degree
	Master degree; Wits Graduate Diploma in Engineering (GDE)	9	Master degree
7	4 year Hons degree; 3 year Bachelor degree + 1 year post-graduate	8	4 year Hons degree; new PG Diploma; 3 year Bachelor degree + 1 year post-graduate
6	3 year Bachelor degree	7	3 year Bachelor degree; Advanced Diploma
	2nd year degree exit	6	2nd year degree exit; Advanced Certificate; Diploma
5	1st year degree exit	5	1st year degree exit; Higher Certificate
Rest of NQF			
4	Matric	4	NSC
3		3	
2		2	
1		1	

Table II
Mine Planning and Optimisation courses for 240-credit MSc

Core Course Units (compulsory):
MINN7092 Mine Financial Valuation (20 credits)
MINN7093 Applied Operations Research in Mineral Resources Management (20 credits)
MINN7089 Mine Planning Principles (20 credits)

Preferred Elective Course Units (students elect to do any three elective course units, but preferably the from the ones listed below):
MINN7091 Planning and Optimisation of Surface Mines (20 credits)
MINN7090 Planning and Optimisation of Underground Mines (20 credits)
MINN7065 Strategic Planning in Mining (20 credits)

Research Project (compulsory):
Students are also required to complete a 120-credit point research project (MINN 7044) on any topic of their choice in mine planning and/or optimisation.

transition to a 180-credit point MSc that would be structured as shown in Table III. The Research Methodology for Mining Engineering course does not yet have a MINN course code as it will only be submitted for approval in 2016 for introduction in 2017.

In the 180-credit point MSc programme, students will have to complete five courses comprised of four 20-credit courses and the 10-credit Research Methodology for Mining Engineering course. On completion of the coursework, students are required to undertake a 90-credit point research project. The proposed structure for the curriculum is in line with the Faculty of Engineering and the Built Environment's Graduate Studies Committee recommendation that all new 180-credit point MSc 50/50s in the faculty should comprise 90-credit point coursework (including a 10-credit point research methodology course) and a 90-credit point research report.

Process

The development process was iterative in order to meet all the requirements of the stage gates of the approval process. The university approved the AoS and it was introduced into the existing MSc programme in 2014. Table IV indicates the students registered (as full-time, part-time, or occasional students) in courses within the AoS that have already run or will run in 2014. The numbers of students registered for a course that has not yet been run are indicative and can increase or decrease during the year since the students are allowed to amend their registration status before the end of September of every year.

Based on the students numbers in Table IV, it is hoped about 10 students can be expected to graduate in 2015 in this AoS. These numbers are likely to grow as the AoS becomes more known to the mining industry with time.

Conclusion

This paper has highlighted recent developments that triggered the introduction of the AoS in Mine Planning and Optimisation at Wits Mining. Key to the success of the development of the AoS was the commitment of the Steering Committee that was set up to drive the development and implementation of the AoS. The AoS was introduced into the existing MSc programme in 2014 and it is hoped that the programme will contribute towards developing skills required for the future viability of the South African mining industry.

Acknowledgements

The author would like to acknowledge the following Steering Committee members for their contribution in developing the AoS in Mine Planning and Optimisation: Dr Gordon Smith (Anglo American Platinum and Chairperson of Steering Committee), Mr Alex Bals (ex-AngloGold Ashanti), Mr Hillary Chirimumimba (ex-Eskom), Mr Mike Woodhall (MineRP), Mr Alastair Macfarlane (Tomahee Consulting Services), Ms Jessica Morgan (Worley Parsons TWP), Mr Luke Zindi (MineQuest Consulting), Dr Fannie Terblanche (North-West University), and Professor Montaz Ali (University of Witwatersrand).

Table III
Envisaged AoS courses for 180-credit MSc

Core Course Units (compulsory):
MINN7(TBA) Research Methodology for Mining Engineering (10 credits)
MINN7092 Mine Financial Valuation (20 credits)
MINN7093 Applied Operations Research in Mineral Resources Management (20 credits)
MINN7089 Mine Planning Principles (20 credits)

Elective Course Units (students elect to do one of the following course units):
MINN7091 Planning and Optimisation of Surface Mines (20 credits)
MINN7090 Planning and Optimisation of Underground Mines (20 credits)
MINN7065 Strategic Planning in Mining (20 credits)

Research Project (compulsory):
Students are also required to complete a 90-credit point research project (MINN 7044) on any topic of their choice in mine planning and/or optimisation.

Table IV
Student registrations in Mine Planning and Optimisation courses in 2014

Course Code	Course Name	Dates in 2014	No. of Registered Students
MINN7092	Mine Financial Valuation	27 Jan – 7 Feb	25
MINN7089	Mine Planning Principles	5 May – 16 May	20
MINN7093	Applied Operations Research in Mineral Resources Management	4 Aug – 15 Aug	10
MINN7065	Strategic Planning in Mining	8 Sep – 12 Sep	11
MINN7091	Planning and Optimisation of Surface Mines	13 Oct – 17 Oct	11
MINN7090	Planning and Optimisation of Underground Mines	3 Nov – 7 Nov	17

References

Chamber of Mines of South Africa. 2012. Facts & Figures 2012. Johannesburg.

Jewison, R 2008. The National Qualifications Framework. Centre for Education Policy Development (CEPD), Johannesburg, South Africa. 44 pp.

Müller, J and Frimmel, H.E. 2010. Numerical analysis of historic gold production cycles and implications for future sub-cycles. The Open Geology Journal, vol. 4. pp. 29-34. http://www.benthamscience.com/open/togeoj/articles/V004/29TOGEOJ.pdf [Accessed 4 July 2013].

South African Qualification Authority (SAQA). 2012. Level Descriptors for the South African National Qualifications Framework, November 2012. SAQA, Pretoria, South Africa. 16 pp.

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