MY DEVELOPMENT FROM RESEARCH TO MINE SAFETY

by

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Introduction

Up to now, I have tended to ignore the passage of time; I did not worry when I passed 50 or 60, but now at 70 I should to pause and ask myself is there anything I can still do? However, I did not ask the question, I suppose I thought that May 20 would be just another day that I have to accept as a measure of the passing time. Then something happened – I heard that my alma mater and the Colorado School of Mines have decided to arrange a get together to remind all my friends of my advancing age. In addition, I was asked to say a few words on this occasion.

Let me say at the outset that I am grateful and overwhelmed by the gesture of arranging this meeting. I can say with all honestly that I did not expect this honor and recognition.

Some of you may have noted lately that I am beginning to talk too much. Since I lost my wife just over three years ago, I have nobody who interrupts and says, "Miklos stop, everyone heard this story at least 20 times" So on this occasion I will relate a story concerning my life, knowing that there will be no interruption.

As a professor, I can talk about many subjects until the audience falls asleep. I do this readily, especially if I talk about myself. So on this occasion I will relate the maturing of my interest from pure rock mechanics research to the investigation mine disasters, to mine safety legislation and finally to the development of ideas to manage, to improve mine safety in a large, global mining company. The story does not describe events in a strict chronological order, but in a sequence designed to serve the storyline.

Research

I have been interested in research, especially as related to the behavior of rocks around mining excavations, since my undergraduate days. This interest strengthened during the time of my employment as a miner in English coal mines. This and other reasons led to my enrolment in April 1959 at the University of Durham as a Ph.D. candidate. I worked at the Mining Engineering Department in various capacities until March 1963. This was the most exciting and productive part of my life as a researcher. It is not my intention to tell about my research career in any detail. All I am going to do is mention one research project that was probably more instrumental than any other was for the development of my career.

In the early part of the 1960s, a tragic mining disaster occurred in the republic of South Africa. At the time the room and pillar (or bord a pillar) method of mining was employed almost exclusively by the growing coal mining industry of the country. The pillars were formed in a checkerboard pattern and left behind to provide permanent support. At Coalbrook Colliery, the pillars over a large area collapsed suddenly, causing the loss of 437 lives. The outcry in the aftermath of the disaster resulted in a decision to initiate research into coal mining safety, with the primary goal of developing a methodology for the safe design of room and pillar workings. Eventually I was appointed to head this research and started to work in Johannesburg in March 1963. About two years later the remit of the research was extended to investigation of the explosibility of coal in South Africa.

It soon became apparent that there were no methods available in the early 1960s that could be adopted to facilitate the safe design of pillar layouts. It became clear also, that to achieve success expeditiously, the methodology of research would have to be semi-empirical and it would have to be based firmly on the history of pillar behavior in the industry. A comprehensive survey of case histories,

involving collapsed and stable areas, were organized and executed successfully during the period following the tragedy.

The self-doubt generated by the magnitude of the collapse (approximately 3.9 km^2) in the managements of coalmines obviously contributed to their ready collaboration. Eventually 127 case histories were collated and documented. I was convinced that the information locked up in this data bank contained the accumulated experience of generation of mining engineers and, if this bank could be "unlocked", we would have the key to the design of coal pillar layouts in South Africa.

Rigorous analysis was required to unlock the database. The method employed was semi-empirical, because the postulate accepted with regard to the estimation of pillar load was in accord with the laws of mechanics. In addition, a plausible mathematical expression was employed to describe the variation of pillar strength as a function of pillar dimensions. This expression contained a number of unknown constants the numerical values of which were supposed to be determined with the help of the information in the database.

The ratio of strength to load gives the traditional safety factor of the pillars. Thus, the two postulates, together with the data in the database, defined the approximate safety factors for the 127 cases as a function of the unknown parameters. Finally, this set of safety factors was analyzed with the aid of the maximum likelihood method, which is well known from mathematical statistics, to obtain the parameter values, Salamon and Munro (1967).

Once the maximum likelihood technique yielded the numerical values for the constants, it became possible to show that the new pillar strength formula adequately describes the information contained in the database. Simultaneously, the strength expression was incorporated into a new methodology for the design of pillar layouts (Salamon 1967) and this procedure rapidly gained acceptance. So much so that after a few years the South African mining authority started to suggest that, the new method should be the bases of all pillar layout design. After the elapse of more than 36 years and in spite of several attempts to introduce more advanced methods, the original methodology (with an extension of its application to squatter pillars) has remained the acceptable design tool. A reanalysis of the circumstances of the Coalbrook collapse, with the aid of the new design technology, has led to the understanding of the mechanism that led to the major failure.

Mine Disasters and Safety Legislation

Disasters. In the early 1960s, there was a serious shortage in rock mechanics expertise in South Africa. Hence, expectably considerable demand arose for my advice after the publication between 1962 and 1964 of the stress calculation method around tabular excavations (Salamon 1962, 1963, 1964a, 1964b, 1964c; Salamon *et al* 1964) and the introduction of the pillar design procedure in 1967. I found these practical assignments challenging and derived considerable pleasure from witnessing the implementation of my increasingly confident advice.

In the early 1970s a major disaster occurred in Wankie Colliery, a mine in Rhodesia, and the government of the country turned to its South African counterpart for assistance. The Assistant Government Mining Engineer and I were nominated by the South African Minister of Mines and subsequently appointed by the President of Rhodesia to serve in a four member Commission of Inquiry. The terms of reference of the Commission were to investigate and report on all aspects of the tragedy and the state of safety in the country's coalmines. The Commission made visits, held many public hearings during which all relevant officers of the company and the government, family members of the victims, local and international trade union officials and international experts gave evidence. Most these discussions were exciting and many of them were sad and depressing. For me, however, a visit into the area around the man-riding shaft was the most touching. Here the wives and mothers of the victims had laid down the blankets and utensils of the buried miners in a long line; we were told this had been done to make sure that when the lost ones returned they had their basic necessities. The simplicity and hopelessness of the gesture made the visit an incredibly harrowing experience.

The coal dust explosion at Wankie resulted in the death of 433 miners and mine officials. The similarity in the number of fatalities (437 versus 433) was not the only similarity between the two accidents. In both instances virtually everyone who was underground were killed and in both cases the victims were not recovered, but left buried in the place of their death. Also neither mine was ever reopened. Clearly these two were major human disasters. While the Coalbrook disaster was a very important event in my and my family's life, the impact of the accident on me personally was limited; I had no direct involvement in the tragedy. The impact of the tragedy at Wankie Colliery was different. I took my role in the Commission extremely seriously. The multitude of information we had to absorb and the shocking revelations we listened to, left an incredibly strong impression on me. On the submission of the Commission's report (Quènet *et al* 1973), I was left with the conclusion that the state of mine safety, at least in some parts of the world,

is unacceptable; if we cannot improve the situation, the question must be faced: "Are we justified to carry on mining?"

Let me recount briefly another experience from my life. In 1984 a series of two major accidents occurred in Taiwan, the total number of fatalities was 177. One of the incidents was underground fires and the other was an explosion. The Taiwan government turned to South Africa for help and a small team was sent to provide assistance. The Government Mining Engineer headed the team; its members were his assistant, another officer from the government service and me. On arrival to Taipei, the Minister of Industries and his officials briefed us. We were requested to report on the disasters. The general atmosphere in the country was tense after the large number of deaths and, I suspect, we were supposed to feature in a firefighter role. Clearly the time provided was not sufficient to provide an in depth report, but was long enough for us to discover that there major problems in the mines. I have to confess that I was glad to have a platoon of police to provide protection for us when visiting the affected mines.

In the light of the unfavorable report from us, the Minister requested that we should inspect all coalmines in the country and make recommendations for the rectification of the state of safety in the collieries. We were reluctant to accept this assignment. I was especially uneasy since I was not an employee of either government, so I did not see who could authorize me to perform such a task safely in a foreign country. After some intergovernmental communications, it was decided that we should to go ahead with the inspections. Since only three of us were mining engineers in the team, we subdivided the task into three parts and started to work. The underground visits revealed incredibly bad conditions; several centimeters thick coal dust was lying on the floor, no measures were applied to suppress potential coal dust explosions, the ventilation was terrible, the cross-sections of many tunnels were more suitable for rats than miners and so on. We have never seen conditions as awful as those we encountered in these properties. Suppose you have divided the mines into three categories: first, acceptable, second, conditions that could be rectified economically and finally mines, which could be rectified only at uneconomic costs. This classification would have resulted in no mines in the first category and about half of the collieries would have fallen into the last group; implying closure of these units.

The exposure to these previously unseen mining conditions made me think about the responsibilities of the managements and owners for safety. Traditionally we expect the manager of the mine to carry the burden of responsibility. While this is undoubtedly correct, the owners should not escape the burden either.

Safety Legislation. The era of apartheid was coming to its end by the late 1980s and early 1990s in South Africa. In the mining industry, the trade unions gained more strength and embarked on an attempt to eliminate racial discrimination. After lengthy debates, the industry, the trade unions and the government agreed that the time has come to take this step. Eventually, the parties reached the compromise that the goal will be best achieved through the appointment of a Commission of Inquiry. After a lengthy search, an international group was appointed. As customary, a judge, Judge R.N. Leon, was asked to chair the Commission and its members included two mining engineers and medical professor. Subsequently the group was referred to as the Leon Commission. I was surprised and delighted by the request to participate, so a British colleague, who was Professor A.W. Davies, retired Chief Inspector of Mines of Great Britain, and I were the two mining engineers who served as members.

The old Mines and Works Act of South Africa was ostensibly created to provide the laws to control matters related to mine safety, but it was also used to entrench racial discrimination in the industry. Thus, the primary task of the Commission was to clear out racial references from the legislation. However, it was agreed that opportunity should be taken to modernize the dated legislation. One of the main problems was that the South African Act, like most contemporary safety legislation, was too prescriptive. The tendency was to prescribe various measures, for example, details of supports, width of pillars or drives, and so on, either in the Act itself or in the associated regulations. These rules were usually formulated in the absence of a full understanding of the mechanisms involved. Consequently, as the science of mining advanced, they became outdated. The time was ripe to rethink the basic premises of mine safety legislations. These and other, largely political considerations, led to the formulation of the terms of reference, which required that the Commission should study all aspects of mine safety in all mines in South Africa and than should recommend the basis for the rewrite of the Act.

The Commission was appointed in late 1993 by Mr. F.W. de Klerk, who was at the time the president of South Africa. The Commission did a great deal of work, it had lengthy public hearings, it made many visits to mines and other places of relevance and studied many thousands of pages of submissions. In the course of its deliberations, it had many debates; some of these were very heated. The report was completed by the end of 1994 and was submitted to Mr. N.R. Mandela, the new president of South Africa, in early 1995 (Leon *et al* 1995). I am proud to say that the majority of the report's recommendations were accepted by the government and were subsequently implemented by the new parliament.

This is not the place or the occasion to review the report. It will suffice to mention two of its recommendations. First, the report proposes that owners should have a direct responsibility for safety. Second, mine legislation should not be prescriptive, but it should require that mine managements develop, with the assistance of appropriately qualified specialists, safety measures appropriate for their particular mine and these measures should be regularly updated. These measures, together with other recommendations, have transformed in subsequent years the attitude to safety in the South African mining industry.

I regard my participation in the work of this Commission as on of the most exciting and rewarding experience of my life.

Management of Safety in a Global Mining Company

In mid 1990s, I received a phone call from an officer of Gencor, one of the South African mining companies. The caller said that they know that I was a member of the Leon Commission and they would like me to join the Company's new Health, Safety and Environment Committee (HSE Committee) as an independent expert. He explained that the top management of the Company has decided to improve these three aspects of the organization's performance and concluded that to achieve this they need a senior advisory body. The committee would consist of two directors of the Company, one of these would be the Chief Executive of Gencor and the other would be the chairman of the Committee, four independent experts and possibly others. The HSE Committee would report directly to the board. I was pleased to accept the invitation.

At the first meeting, it became apparent that nobody had a clear idea as to how the Committee should operate. Various suggestions were made and debated before the modus operandi of the committee gradually crystallized. It was clear from the outset that a Company, which had poor HSE record, could not rely on outside agencies to solve its problems. Such outside bodies can contribute, can be of assistance but cannot drive the effort. Furthermore, the improvement of health, safety or environment has to be managed just as the production is managed. The responsibilities for HSE must be attributed to all levels of management. Thus, the periodic reports of units (profit centers) on the subject should be compiled through contributions at all levels, but it should be presented to the HSE Committee by the heads of the units. Furthermore, it was agreed that a presentation should be made by the unit head to the Committee with regard each fatal accident.

For example, if a fatal accident occurred in a coalmine, the head of the coal-mining unit would present the report and he would be assisted by the manager of the colliery where the accident actually occurred. To put this in perspective, Gencor's coal-mining unit was producing about 60 million tons of coal per year at the time and the manager was in charge of a coalmine that produced in the order of 3 to 6 million tons per annum. The Committee mercilessly cross-examined the presenters of the report. Reporting on fatal accidents was a grueling experience for the men who had to do it. It might be argued that it is unfair to grill the head of the unit about an accident that happened remotely from him and it was not within his immediate control. Unfortunately, the real world is cruel; the pain that is generated by errors or omissions under a chain of responsibility should be felt by all serving in the chain. In addition, during the preparation for the questioning session, he certainly made sure that he found out everything possible about the accident.

After an initial shock, the effects of the new regime began to materialize in the Company and, *inter alia*, the accident statistics started to improve.

At about this point, a major change came about. Gencor has purchased an international mining company called Billiton, which had been the mining arm of the oil giant Shell. Soon after this step, Billiton, in turn, has bought most of the assets of Gencor. As Billiton was a London registered company, these maneuvers achieved that the South African company changed into an international company and, at same time, it became the fifth largest mining venture of the world (due to the impossibility of making valid comparisons, China and the countries of the ex Soviet Union have to be excluded from this comparison). In line with these changes, the Company was reorganized and we become the HSE Committee of the new Billiton. The model developed under the Gencor umbrella, after some modifications, proved durable and continued to operate very effectively. This is a commendable achievement, since the new Company had operations in Australia, Asia, Europe, North, Central and South America and, of course, in Southern Africa. In spite of this cultural and economic diversity, the Company prospered and its safety statistics started to improve more and more convincingly. In spite of many intercontinental trips, this period of my working life was very exciting and satisfactory. I feel that I have been privileged to be able to pass on the benefits of a lifetime of experience in this, most effective manner.

In closing, let me mention that about two years ago Billiton had merged with the Australian giant BHP and the new company, now known as BHP Billiton, today is the world's largest mining company.

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Összefoglalás

Fiatal emberként a kőzetmechanika kutatásra koncentráltam energiám nagy részét. Ezek az évek, melyek nagyjából egybeestek doktorjelölti éveimmel, nagyon eredményesek voltak. Több érdekes felismeréshez abban az időben jutottam. A 60-as évek elején egy borzasztó tragédia történt a Dél-Afrikai Köztársaságban. Körülbelül 3,9 km^2 területen egy pillérfejtéssel művelt szénmezőben a pillérek összeomlottak. Az omlás 437 bányász életébe került. Ez a szerencsétlenség megrázta az egész országot. Több másik határozat mellett a bányahatóság – az ipar vezetőinek egyetértésével – úgy döntött, hogy kutatást kell kezdeni a szénbányászati biztonság területén. E határozat értelmében, 1963 márciusában Johannesburgban kezdtem a kutatás megszervezését.

Az első célunk a pillérfejtés tervezési módszerének kidolgozása volt. 1966-ban egy méretezési eljárást letettünk az asztalra. Ez a módszer nagyon jól bevált, és még ma is használatban van. Ezután egyre gyakrabban kértek fel tanácsadóként gyakorlati problémák megoldásásra. Az 1970-es évek elején egy másik nagy szerencsétlenség történt a szomszédos Rhodésiában (ma Zimbabwe) és az ottani kormány segítséget kért a baleset kivizsgálásában a dél-afrikai kormánytól. Az ő javaslatuk alapján én lettem a négy tagú vizsgáló bizottság (Comission of Inquiry) egyik tagja. Ez egy szénpor robbanás volt, mely 433 embert ölt meg. Később, 1984-ben a tajvani kormány hasonló kéréssel fordult Dél-Afrikához egy hármas szerencsétlenség-sorozat ügyében. Ezekben a balasetekben 177 bányász vesztette életét. Egy négy tagú csapat tagjaként kerültem Tajvanba és vettem részt a szerencsétlenségek kivizsgálásában, majd később a tajvani bányák biztonságának javításában. Az ily nagyméretű balasetekkel való közeli kapcsolat nagyon nagy hatással van a mefigyelőre. E szerencsétlenségek hatására, azt hiszem elkerülhetetlenül, arra következtetésre jutottam, hogy sokfelé a világon a bányászok biztonsága nem kielégítő; és valamit tenni kell a helyzet megjavítására.

Életem legnehezebb feladatára 1993 és 1995 között került sor. Dél-Afrikában a bányászati hatóság, a bányaipar vezetői és a szakszervezetek megegyeztek abban, hogy az elavult bányabiztonsági törvény felülvizsgálatra szorul. E munka kivitelezésére egy nemzetközi Vizsgáló Bizottságot (Commission of Inquiry) neveztek ki, melynek én is tagja lettem. A Bizottság végül egy új törvény körvonalait vázolta jelentésében, melyet Mandela elnöknek nyujtott be 1995 elején. Később a dél-afrikai parlament elfogadta ezeket a javaslatokat, és ma, azt lehet mondani, hogy a Dél-Afrikai Köztársaságnak van a legmodernebb bányabiztonsági törvénye.

Még egyszer mellém szegődött a szerencse, és az 1990-es évek közepén egy nagy dél-afrikai bányavállalat felkért, hogy legyek tagja egy új bizottságnak, mely a terv szerint az igazgató tanácsuk mellett fog dolgozni, és melynek a vezérigazgató, s a vállalatnak még egy másik igazgatója is tagja lesz. A bizottság célja a vállalat teljesítményének lényeges javítása az egészségügy, a bányabiztonság és a környezetvédelem területén. Három kolléga és én független tanácsadóként dolgoztunk mint bizottsági tagok. Ez volt talán életem legizgalmasabb és legkielégítőbb feladata. Egy élet tapasztalatát lehetett felhasználni, hogy egy nagy létesítmény alkalmazottai biztonságosabb, egészségesebb és kellemesebb körülmények között dolgozhassanak.