Polish Geological Institute Special Papers, 7 (2002): 199–206
Proceedings of the IV European Coal Conference

EVALUATION OF THE BOGDANKA MINE, POLAND

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A b s t r a c t . During the early part of 1999 Steffen, Robertson and Kirsten (UK) Ltd (SRK) were commissioned by Price Waterhouse Coopers to carry out the technical due diligence study of the Bogdanka Coal Mine as part of their contract with the Treasury Ministry of Poland for pre-privatisation analysis. A visit was undertaken by four experienced consultants specialising in the fields of geology, mining, coal preparation and environment. The team also undertook a review of management, manning levels, performance and other broad issues affecting the operation of the mine.

In this paper the author outlines the general geology of the mine, and attempts to show how an experienced consultant comes to terms with a meaningful assessment of a mine and coalfield of which he has little or no previous knowledge, particularly given the very short time available for the commission.

The relevance of such aspects as mineral rights and concessions, the exploration history, cover deposits, coal bearing strata, geological structure, coal quality and potential hazards to the assessment will be examined. The assessment of reserves and resources to standards acceptable to international banking organisations will be looked at in more detail. Finally some of the critical non-geological factors of the assessment will be outlined.

K e y w o r d s : geological conditions, reserves and resources, Bogdanka Coal Mine.

INTRODUCTION

SRK Consulting (SRK) were mandated by Price Waterhouse Coopers (PWC) to carry out the technical due diligence study of the Bogdanka Mine as part of PWC's contract with the Polish Ministry of State Treasury for the pre-privatisation analysis of KWK Bogdanka SA. A team of four from SRK visited the mine during the Spring of 1999 to examine the geological, mining, environmental and coal preparation aspects of the operation as well as reviewing management, manning levels, performance and other broad views affecting the operation of the mine.

The Bogdanka mine complex lies 180 km to the south east of Warsaw, close to the town of Lublin, and is the only mine operating outside of the Silesian coalfields of southern Poland. Shaft sinking commenced in 1975 with production, currently running at approximately 3.5 m.t. pa, starting in 1984. In 1993 the joint stock company Bogdanka J.S. was created with the Ministry of State Treasury owning 86% of the shares. Coal is delivered on site to a coal preparation plant owned by the subsidiary Lublin Coal where waste rock is removed to produce some 3.25 m.t. p.a. of medium grade (22 MJ/kg) steam coal which is mostly moved by rail to power stations and other bulk users in eastern Poland. Some 0.25 m.t. of sized high grade (27 MJ/kg) household and industrial coal is produced and sold locally.

GENERAL GEOLOGY

Mineral rights fall under Poland's Geological and Mining Law, promulgated in February 1994, which covers all aspects of control over the minerals sector, including the award of exploration and minerals concessions, royalties and the responsibilities of mine operators. The law distinguishes between "basic" minerals, including all energy materials such as coal, and "common" minerals, comprising greenfield occurrences of materials such as sand, clay and aggregates. The former falls under the jurisdiction of the Minister of Environmental Protection, Natural Resources and Forestry, whilst the latter (and also the treatment of tailings or old waste material) fall under the Voivodes or Provincial Governors. The exploration and

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production stages of projects and applications require the submission of environmental impact studies. The Law makes provision for an initial payment for mining rights and sets limits on royalty payments. The latter go to the local commune and the National Fund for Environmental Protection and Water Management. It is assessed on the sale value after benefication, where this has been undertaken. Hard coal attracts a basic rate of 2% compared to 4% for lignite or brown coal, and 6% for oil, natural gas or coalbed methane.

At Bogdanka the mining concession covers some 57 km^2 and allows for the extraction of coal from two seams, Seams 382 and 385/2, until the year 2015. Terms of the licence permit continuing exploration of deeper seams by underground drilling whilst extensions in time or to additional seams would be subject to government approval. Economic prospecting was carried out between 1968 and 1974, following earlier investigation by the Upper Silesian Branch of the Polish Geological Institute. Within the Westphalian coalbearing strata of the Lublin Basin some seven mines were originally planned but only two commenced. The most southerly of the three shaft locations, Stefanow, was abandoned in 1987, whilst the other two at Bogdanka and Nadrybie remain. Numerous surface boreholes were drilled at an approximate spacing of 1500 m with holes continuously cored and geologged. Underground coring is extensive at a spacing of some 700/800 m and at 93 mm diameter. Surface seismic surveys carried out in 1985 were at the time thought to have shown a significant network of faulting, but subsequent working has shown the deposit to be remarkably free of faults.

The workings in Seams 382 and 385/2 vary in depth from 820 to 970 m with coal bearing strata being encountered at approximately 700 m. The shallowest cover strata are some 30–50 m of Quaternary age glacially derived sediments, principally sand together with gravel and clay. Tertiary age deposits are generally absent (Fig. 1).

Beneath lie 500–550 m of Cretaceous (kreda) strata, principally limestones. The upper section comprises mostly chalky limestone, the middle and thickest section chalk with flints, and the lowest sandy and oolithic, dolomitic limestones. At the base is a thin (1.5–3.0 m) bed of sand, soft sandstone and conglomerate (Albian). Above the coal bearing strata is 100–150 m of Jurassic limestone with a basal section of sands and clays.

Carboniferous (karbon) strata have been proved to depths of 1000–1300 m and contain a sequence of coal seams, shales, mudstone, claystones, seatearths and less frequently sandstone. Seams are assigned correlation numbers with eight identified as of possible economic importance. Seam partings generally are not prone to rapid changes, and seam thickness is up to approximately 3 m. The upper two seams, overlying those currently being worked, have not to date been considered for working due to their proximity to the overlying water bearing Jurassic limestones.

The mine is characterised by a relatively simple geological structure with seams dipping towards the axis of the northwest–southeast trending Bogdanka Syncline. To the west of the axis, which passes through the centre of the Bogdanka and Stefanow shaft locations, strata dip at increasing gradients (1 in 18 increasing to 1 in 6 or more) as the incrop against the overlying Jurassic strata is approached. Strata on the eastern limb dip more gently at 1 in 35 to 1 in 55. Minor normal faults with throws of less than 2.5 m are occasionally present.

Seam 382 has been worked centrally within the mine take, with occasional second horizon workings in Seam 385/2, some 30 m below. The upper seam averages 2.5–3.5 m in thickness to date, with mudstone dirt partings of 0.1–0.3 m. Locally, the dirt parting increases such that only the top section is cut. Seam 385/2 has been worked less extensively and is 1.7–2.0 m thick with one or two thin dirt bands. Both seams are subject to thinning elsewhere within the mine take.

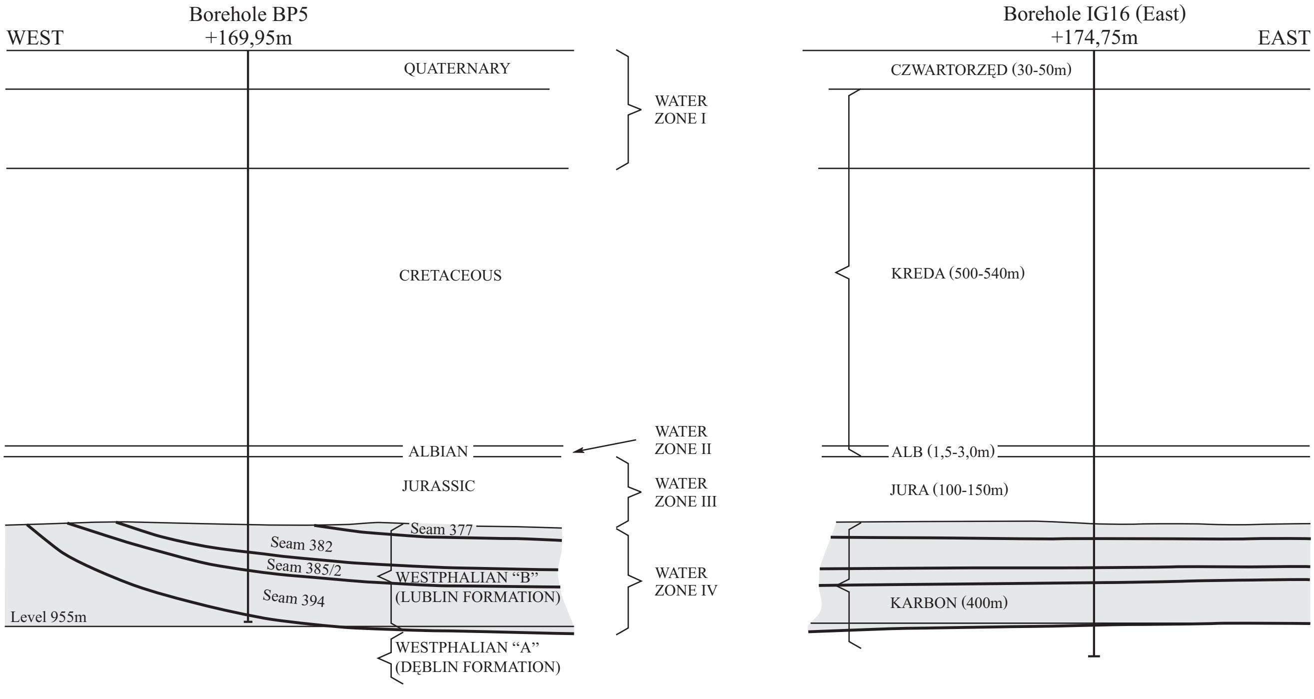

Fig. 1. Sketch geological cross-section and strata divisions, Bogdanka

Coal is classified under the Polish system as "Gas-flame" or "Gas" coal with average ash and sulphur percentages of approximately 10% and 1.0–1.5% respectively. In general terms all eight coal seams which are sufficiently thick and persistent to be considered for extraction are of reasonable quality (Table 1). However, on closer inspection, the lowest of the eight seams may be ruled out at the present time since the average sulphur content is approximately double that of the two seams currently being worked.

Table 1

Coal seam parameters

Seam No.	Parting to seam below [m]	Ave. thk. [m]	Seam area [% take]	Ave. ash [%]	Ave. CV [MJ/kg]	Ave. Su. [%]
377/1	18	1.30	72	12	26.5	0.99
378	66	–	16	16	26.2	1.19
382	32	2.60	51	13	26.4	1.40
385/2	14	1.55	96	8	26.0	1.11
387	15	0.70	12	12	27.0	1.74
389	24	1.18	61	11	27.7	1.45
391	37	1.60	96	8	28.8	1.24
394	–	0.70	?	10	28.5	2.66

Data produced from borehole information

Four different water bearing aquifers have been identified in the sequence:

- Quaternary and Upper Cretaceous aquifer to a depth of 150–200 m, controlled by fissure systems, which provides supplies of drinking water in the region;
- Lower Cretaceous aquifer, related to a thin layer of water bearing Albian sands with pressures of up to 5.6 MPa, which was responsible for partial infilling of the Stefanow shafts;
- Jurassic aquifer, associated with fissuring and cavern development in the limestones, and also with fissuring and high porosity within sandstones;
- Carboniferous aquifer usually associated with permeable sandstone beds.

The middle aquifers are thought to be recharged from the surface by mainly meteoric water via faults in the Cretaceous strata. Inter-connection to lower aquifers remains a possibility in the future as further coal working in the basin results in subsidence collapse.

The mine is basically dry in operational areas with only nuisance water, except in an area where a face approached the overlying Jurassic strata in the south west of the mine. There is now a consistent flow of 2.5–3.0 m^3/min. There was a major shaft lining failure at Bogdanka due to excessive pressure on the lining by the Albian sands aquifer, resulting in infilling and abandonment. Other shafts (diameter approximately 7.5 m) are now protected from damage by pressure relief drainage.

There is no direct sandstone contact with either of the worked seams as there is a persistent mudstone roof to both seams, with a minimum thickness of 0.50 m. Roof mudstones have only rarely posed operational problems, and this has usually been when face progress has been slow. Floor strata comprise mudstones which are often weak and soft and require a separate floor invert.

Both seams have been assessed as low methane risk with values of <2.5 m^3/tonne being the norm. At the time of SRK's visit there had been no incidents of spontaneous combustion but most coal had been assessed in the relatively high risk class IV, within a classification from class I (low risk) to class V (high risk).

RESERVES AND RESOURCES

An investigating geologist should first closely examine the methods employed by the company to obtain exploration data; to monitor this against newly acquired data from mine workings (shafts, headings, faces etc); to record the data, and to calculate resources and reserves. The qualifications and skills of the staff employed will also be assessed. Any reservations should be discussed and clarified with appropriate managers.

Consideration of which seams meet the basic criteria for economic extraction is required. At Bogdanka some seams could be readily discarded from further consideration (see Table 1). Seam 394 has high sulphur, is thin and impersistent and is at depth; Seam 378 is thin and impersistent; Seams 377/1 and 378 are generally within 100 m of the overlying water bearing Jurassic limestones; Seam 387 is largely absent. The remaining four are of similar quality and persistence with Seam 389 being the thinnest. Seams 382 and 385/2 are the shallowest and are covered for extraction by the existing mining concession. Underground drilling is continuing to explore down from Seam 385/2 to Seam 391, although 50% of Seam 389 and 75% of Seam 391 resources lie at depths of 955–1000 m.

Detailed examination of the broadly viable coal seams (382 and 385/2) is then required in terms of seam thickness, dirt partings, persistence and quality variation in order to eliminate uneconomical zones of the mine take. In this respect Polish evaluations exclude areas with a clean coal thickness of 1.20 m and areas where the ratio of dirt bands to clean coal is greater than 0.20. At Bogdanka, Seam 382 thins to less than 1.20 m over the southern part of the take and in the north east corner to less than 1.50 m as the result of an increasingly thick dirt band, with both the dirt band and underlying leaf of coal having to be left in the ground. Seam 385/2 is more extensive and nowhere exceeds the dirt band coefficient of 0.20. However, seam thickness intermittently reduces to less than 1.20 m along the northern margins of the take. Generally, seam quality is reasonably consistent. However sulphur values for Seam 382 increase to the north and calorific values are generally lower where the seam is thinner. Blending of the coal should ensure reserves in these areas can still be maximised.

Estimates and plans for reserves and resources at this stage of the analysis take no account of the existing or proposed layout of panels at the mine. At Bogdanka it is necessary then to exclude losses which are in addition to the geological ones (within 100 m of limestone cover, clean coal thickness less than 1.20 m, ratio of dirt bands to coal greater than 0.20) and result from the configuration of the mine. Shaft pillars, of approximately 120–130 m diameter, are excluded from longwall working and deducted from in situ reserves and resources figures derived under the Polish evaluation system. Assessment of the coal available from scheduled and planned panels in the two seams was then made by SRK with a mining loss adjustment of 10% from the in situ figure. This in situ "planned and scheduled" tonnage was then deducted from the Bogdanka Mine's figure for total in situ coal (classes A, B, C1 and C2) with a deduction of 35% then made for both mining and layout losses. Layout losses could result from the 5 m pillar left between panels of coal, roadway protection pillars, irregular shaped areas of coal where a face cannot be developed, areas already sterilised by previous working, and face foreshortening due to unforeseen faulting.

Further losses, not considered in this assessment, could result from the benefication process.

Bogdanka staff calculated resource and reserve figures according to Polish legislation. It is carried out against increasing degrees of geological recognition and economic certainty (Fig. 2). Assessments are carried out annually and submitted for government approval.

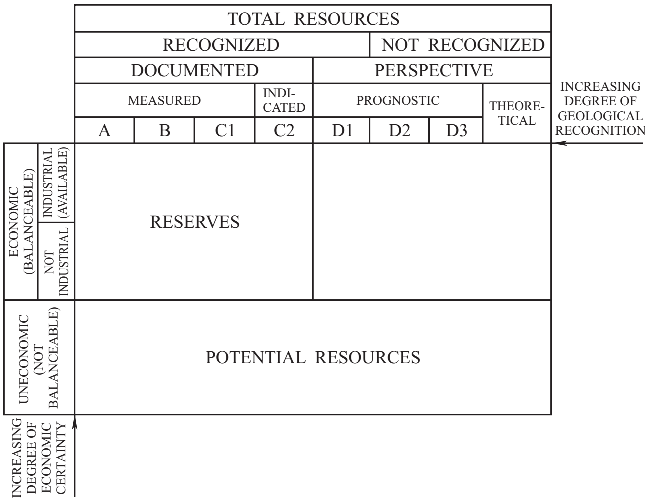

Fig. 2. Polish coal reserve classification

Category A coal is enclosed by mine roadways at a maximum distance of 300 m apart; category B is proved by driveages and boreholes at a maximum distance apart of 800 m; category C1 results from boreholes only, at a maximum

Fig. 3. Seam 382, reserves and resources

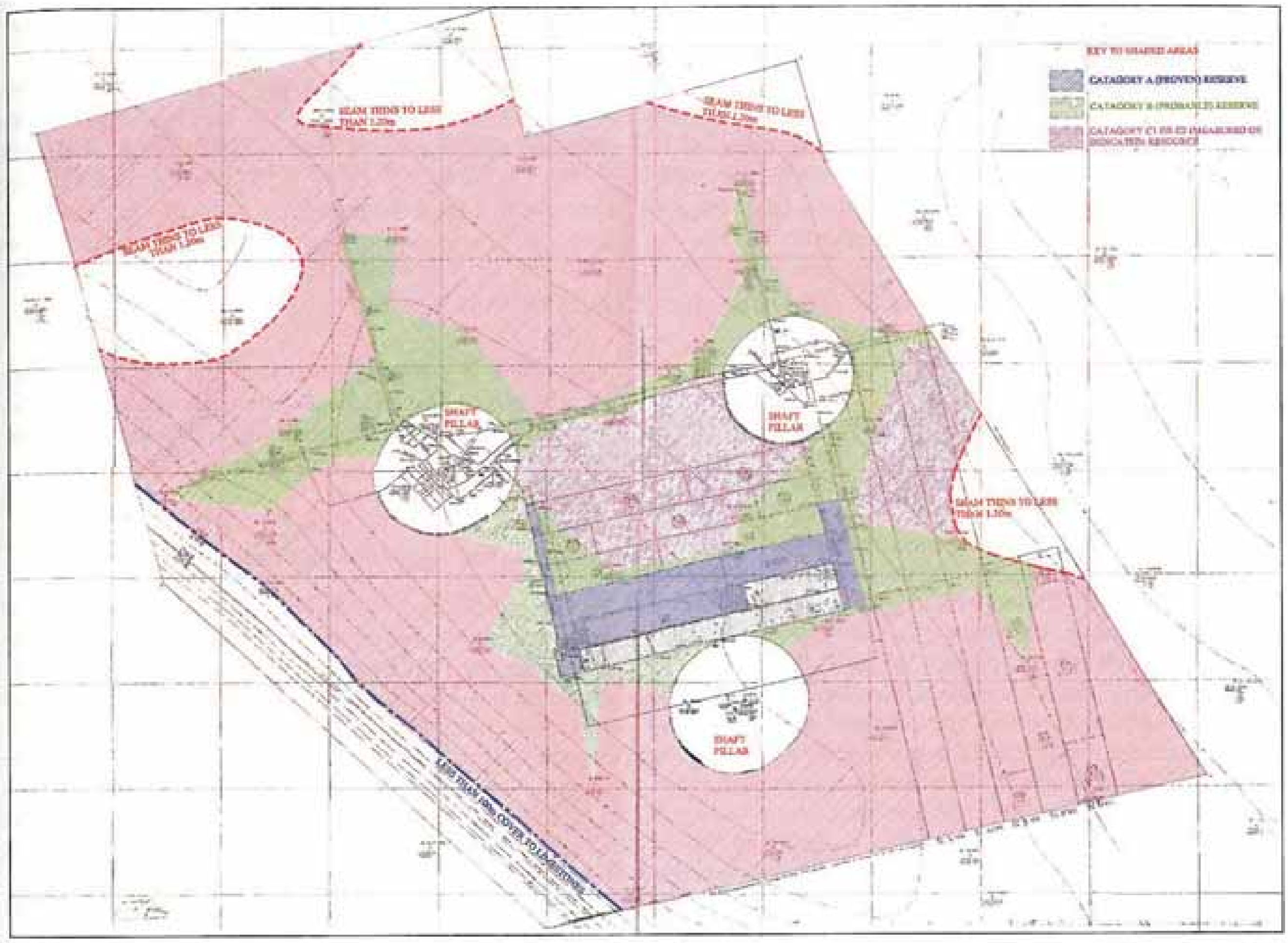

Fig. 4. Seam 385/2, reserves and resources

spacing of 1500 m centres; category C2 by boreholes at a spacing of 1500 to 3000 m centres. Shaft pillars and areas beyond a minimum cover line are excluded from all categories. These categories represent in situ resources and reserves.

Financial assessments of coal or ore reserves and resources (whether they be for privatisation, flotation on the international stock market, raising of additional capital, transfer of assets to another company etc.) have to be carried out by a competent person under guidelines acceptable to international financial institutions. SRK had previously carried out work on behalf of the lending banks in respect of the successful bid by RJB Mining for the English Coal assets during the privatisation of the UK coal industry. During this work the guidelines of the Institution of Mining and Metallurgy (IMM) were followed. They contain no set rules regarding the distance between data points and they are not specifically tailored to coal evaluations, but guidelines were agreed between the various parties. Similar procedures were adopted by SRK at Bogdanka with the equivalents between the IMM and the Polish classification shown below:

IMM classification	Polish classification
Mineral potential	Theoretical
Indicated resource	Category D
	Category C2
Measured resource	Category C1
Probable reserve	Category B
Proven reserve	Category A

With this type of work time does not permit the "competent person" to reassess reserves from basics and they must satisfy themself that the methodology adopted by the "local" geologist is satisfactory and based on sound data, and then seek to make correlations between the differing systems in order to assess coal resources and reserves. In this respect the author has more recently adopted the Australian Code of Practice (JORC) on opencast and underground mines in India and China. This code may well become an accepted international standard in the near future and gives guidance on the verification of raw data, the appropriate spacing of data for in situ assessments, and the relevance of other studies (geotechnical, marketing, financial costs etc) in the assessment of mineable or marketable reserves. In all acceptable evaluation systems the role of the "competent person" is paramount and this person makes the ultimate decision on categorisation.

The Bogdanka assessment categorised a substantial quantity of coal from Seams 382 (Fig. 3) and 385/2 (Fig. 4) in the proven and probable reserve categories (approximately 15–20 years of supply at current extraction rates). In view of the simple geological structure, proven seam continuity, relatively close proximity of the two seams and extensive proving by both boreholes and underground drivages further resources will be upgraded to reserve status and probable reserves up to proven reserves in the next few years. One note of caution concerns the fact that second horizon working in Seam 385/2 has to date only been carried out over a relatively restricted area.

Seams other than the two currently being worked cannot yet be categorised as reserves, in spite of the extent of drilling, since they are not covered by the current mining concession and the viability of working them has not yet been proven.

NON-GEOLOGICAL FACTORS IN ASSESSMENT

Extraction methods and conditions

The mine uses longwall mining with caving behind the face. There is a “total” extraction system where the faces are placed “skin to skin” with only a narrow 5 m pillar left between. Roadways are generally not reused as the mining process destroys them due to the pre-mining and mining induced stresses. Due to the absence of faulting the mine has been able to be laid out in a very orderly manner with long face runs, in excess of 2000 m in some cases. The length of face has gradually been increased from 100 m to the present 285 m. The size of panels gives a long production life between installation and recovery of face equipment. Roadways are supported with heavy duty yielding arches set as close as 0.6 m with spacing dictated by local geological conditions. The floor is soft with a strength in the region of 15–25 MPa and as a result a separate floor invert is put in place behind the development machine. Currently arches are removed as the face passes but these have been subject to high loading and are not reusable. The mine has three longwall sets of equipment, utilising Joy 4LS and KSW 500 — 2A2V/2BPN face machines, and eight heading machines (two deployed by contractors), mostly Vorst alpine AM65’s or AM60’s, to develop new roadways.

Mine management reported no incidents of spontaneous combustion at the time of SRK’s visit and methane emissions were very low. Heating is a problem at the mine. Standard 300 kW chillers are in use on headings and faces to aid the comfort of underground workers and permit the working of shifts longer than six hours (a requirement of Polish law).

Coal preparation

At the coal preparation plant all processes are manually operated and controlled including the density and cut controls on the major washing vessels. It is designed to upgrade the run of mine product by removing waste from the plus 20 mm coal using a dense medium machine and a water jig. A high density wash (specific gravity 1.7) produces a float product which becomes the feed for the second stage, and a discarded sinks product. The product is refined by a low density wash (specific gravity 1.4) which results in a floats product sold as large coal and a sinks product which is crushed to less than 20 mm and transferred to the fine coal preparation plant for re-washing. Waste water is pumped to two high-rate thickeners where flocculents are added and the coal slurry is separated from the effluent water which is pumped to the waste water reservoir. The plant currently has a capacity of nearly 4 m.t. sales tonnes.

Environmental legislation and liabilities

Any industrial operation in Poland is subject to a number of operating permits covering such aspects as land use, air emissions, water usage and discharge, noise and vibration, and waste generation and disposal. Responsibility for administration and enforcement lies with the Regional (District) office of the Environment Ministry, which for Bogdanka is located in Lublin. The control of local environmental ordinances relating to land use matters is the responsibility of the planning authorities of the self-governing Communes which operate at the local level within the Regional Office area of jurisdiction. In Poland environmental liability can encompass violations of the operational permits, damage under civil and criminal statutes, and the requirement for long term rehabilitation of the operational site.

As at many mine sites throughout the world the most significant environmental liabilities and associated costs relate to subsidence, rehabilitation of the waste dump, decommissioning and rehabilitation of the mine site at closure, and operational constraints and permitting. Subsidence has already taken place in this largely rural area from the existing operations and this could be further exacerbated if widespread second seam working were to be instigated, particularly beneath areas with a shallow water table which are vulnerable to water logging and flooding. Tentative proposals for the creation of a large water reservoir with the primary intention of encouraging recreation and wildlife thus has considerable merit. Part of the waste dump has already been rehabilitated and the incentive to continue with such work is that the area could then be treated as one of non-industrial use and attract lower fee payments. Closure costs and liabilities are complicated by the fact that within the Bogdanka mine complex several operating companies have an ownership interest in the various activities. The largest operational permitting costs are those associated with the deposition of mine waste and royalties, whilst others include licensing, water supply and air emissions from vehicles.

CONCLUSIONS

The Bogdanka Mine ranks with the best deep coal mines in the world in terms of the absolute performance of its longwalls and development headings, and has long term reserves available for future exploitation.

The classification of reserves and resources will become a more transparent process once an internationally accepted standard is adopted. The competent person must have considerable international experience and also be a good communicator in order to work successfully with all the interested parties.

In my experience the "local geologist" has nearly always done a good job and has an excellent knowledge of the coal deposit and mine. However, a fresh pair of geological eyes can often add value to the project for both the operator and the Consultant's client.