# Comment on G.J. de Korte 'Dense-medium beneficiation of fine coal revisited'

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by P.J. van der Walt*

### Introduction

The paper[1] (hereinafter BG) by two respected sampling experts contains sound theory and logic that can't be directly refuted. Nevertheless, a practitioner knows that there is a broader context in which the practice of sampling takes place. This broader context, being less well defined than the theory of correct sampling, receives correspondingly less exposure which this commentary—'prompted by' BG—seeks to rectify.

'Correctness' of a sampler is the central concern of BG, where it is presented as a sharp 'black-and-white' distinction. Accordingly, comments below are grouped under the following headings:

- Correctness in practice
- Without correctness, what can be done?
- The broader context.

### Correctness in practice

It is hard to disagree with any part of the theoretical viewpoint stated by the authors—but their zoology ('In sampling theory, a cat is a cat..') is not so clearcut in practice, where the following are possible:

- A cat may be a dog
- A dog may behave like a cat
- A cat may turn into a dog and then back into a cat at inconvenient times.

Some illustrations and discussions follow.

#### *A cat may be a dog*

H.E. Bartlett[2] describes studies leading to the detection and elimination of bias in a sampler that one had good reason to suppose was a 'correct' sampler, being a cross-stream rectilinear sample cutter of the Denver type applied to a pulp stream. This does not prove that the theory in BG was wrong—it wasn't and never could be—just that it is hard to apply theory to practice. Depending on the interpretation of the errant mechanism in the sampling situation Bartlett describes, one could defend theory by either claiming that the cutter gap was not wide enough (although it met the usual criteria), or by referring to the clause in BG concerning 'the modifications brought to the mechanics of fluids and solids in the vicinity of the sample collection (apparatus)'. But, these distinctions are not clearcut—how wide would the cutter need to be before the dog turned into a cat? How does one judge the point at which the 'modifications' may be such as to cause a bias? Even for an experienced sampling expert, these would be questions requiring more than just inspection.

#### *A dog may behave like a cat*

An incorrect sampler may give unbiased results. Theory does not dispute this, but it is a fact that perhaps does not have useful consequences.

An example: H.E. Bartlett and the author were involved over many years with valuation issues attending the transfer of flotation concentrates (in skips and trucks) from several concentrators to a smelter. Historically, these had been valued using samples scooped from the top surface of the material in the skips or trucks—not a correct method of sampling. At considerable expense, auger sampling stations (a substantially correct method) were installed at most despatch and receipt stations. However, on some transfer legs there remained scoop sampling at despatch in direct comparison with auger sampling at receipt. As with other transfers, these comparisons were monitored using statistical techniques that would have been able to detect a sampling bias of 1% relative if it ever arose—which it never did over many years. Despite an eventually large amount of statistical power, it was never possible to prove even a small bias between the incorrect scoop method and the correct auger method.

Nevertheless, this example doesn't prove anything of general use—one can't commend scoop sampling. But the message just presented is: in practice, beware of trusting only correctness.

#### *A cat may turn into a dog and then back into a cat again at inconvenient times*

The essential issue covered under this heading is the problem of correctness across time.

Most readers will be able to bring to mind sampling installations which are correctly designed, and which are correct when operated and maintained according to their design specifications, but which may become incorrect during periods of neglect. This may involve issues as simple as keeping the cutters clean, keeping sample pipes unclogged, or executing any manual aspects like removing and manually breaking oversize rocks (in the case of a belt sample).

The problem that may then face the sample auditor is that he may look at a correctly designed and installed sampler, and observe it operating correctly at the present time; but he can't be sure that this was always the case in

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intervening time periods. This concern has most force when the client is trying to prove something—such as for example the results of a stocktake.

### Without correctness, what can be done?

Lost tourist: Could you tell me the way to Kilkenny?
Local: If that's where you're wanting to go, you shouldn't be starting from here!

Is there a danger that the advice flowing from a sampling audit could be akin to the advice received by the hapless tourist in this scenario? On the one hand, an external expert sampling audit is a valuable source of advice as to what could be done better. On the other hand, in situations where the client cannot practically implement theoretically correct sampling, a critical audit may leave them feeling more lost than before they received the advice. In addition, as argued earlier, the matter of correctness is more difficult to pin down in practice than it is in theory.

Therefore in what follows, some comments are made about what can be done in practice even despite the absence of correctness. Correct sampling where reasonably practicable remains the obvious recommended route. These comments do not contradict BG; they represent alternatives that fall outside the scope of a sampling audit.

Possible strategies fall into two categories:

- Consider the errant mechanism
- Empirical monitoring

and a tactic worth considering is

- Stratified sampling.

#### *Consider the errant mechanism*

The absence of correctness does not by itself cause a bias: what it does is to remove the guarantee and open the door for some aspect of heterogeneity to combine with the incorrectness of the sampler in a way that causes a bias. The 'errant mechanism' is this combination. Examples are plentiful because unfortunately it will tend to be the rule rather than the exception that an incorrect sampler will lead to a bias. Common generic mechanisms centre around particle size, or (in pulps) settling velocity.

Nevertheless, given that the errant mechanism is understood, it may be possible to correct for the bias, or at least limit the impact as the following examples illustrate.

- Dip samples of molten bullion (not a correct sampling method). The errant mechanisms were identified to be a degree of pre-refining taking place through the boiling-off of certain metals, and an under-representation of slag constituents. A series of experiments were done against a laborious but more correct (but still not theoretically perfect) method, namely drilling of bullion bars. A statistical regression model was developed that calibrated the extent of bias by reference to concentrations of certain metals. This work, by H. E. Bartlett and the author in the late 1980s, whilst not reproducing the theoretical ideal of correct sampling, nevertheless went a substantial way to correcting the biases that had existed up to then, and has since been used to value thousands of tons of bullion.
- Excluding large rocks in broken ore samples. H. Sichel reputably (the author could not trace written sources for this work) developed broken ore sampling protocols based on the deliberate exclusion of large rocks from samples—with suitably calibrated correction factors for the resulting assays.

The difficulties in this kind of work are:

- developing and maintaining an adequate understanding of the mechanism—in the above example a change in drilling patterns and fragmentation could disturb the bias relationship
- exposure to drifting biases—there may be some unmeasured external variable (for example: rock hardness) that has input to the mechanism and that varies in an uncontrollable way, causing varying amounts of bias.

These difficulties and limitations would need to be measured against the practicality of installing correct sampling.

#### *Empirical monitoring*

There is much to be said for making the best possible use of the data available, even if parts of it carry less than perfect claims to correctness. Statistical techniques for quality monitoring and control (SQM) suggest themselves for this duty. The two most common applications are:

- SQM applied to a despatcher/receiver situation. A common situation will be that regular batches of material are transferred, and each batch is separately valued by the despatcher and the receiver, each using their own sampling procedure (and analytical laboratory). Less frequently, a protocol for crossing-over may exist, i.e. samples are swopped. Where some degree of cross-over exists, the SQM techniques can separately monitor the biases due to each of *sampling* and *laboratory analysis*. ('Bias' here refers to relative bias between the two parties). D.M. Hawkins introduced efficient versions of SQM techniques that became the backbone of much of the work done by H.E. Bartlett and the author in a wide range of material valuation situations. The significant benefit of these techniques was not only that they would signal the beginning of a bias as soon as statistically possible, but also that the source of the bias (sampling, or analysis) was identified.
- SQM applied to reconciliations of materials around a flowsheet. These will be situations where one expects total inflows to equal total outflows, and the SQM will operate to track the discrepancies over time. Where these depart from acceptable balance, one of the possible causes will be a loss of correctness in some samplers, but other possibilities will be the massing, laboratory analysis, plus the possibility that there may be some unaccounted losses or holdups in the process.

Empirical monitoring techniques such as these are likely to provide important insights to the valuation of materials—especially change points in time which might be correlated with some known procedural change.

#### *Stratified sampling*

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Stratified sampling is a natural strategy that perhaps receives too little attention in the context of sampling particulate materials. It involves dividing the sample into disparate strata and sampling each stratum; as long as the mass split is available, the assay of the complete stream can be back-calculated from the results. Examples:

- Refinery sweeps. The author was involved in figuring optimal parameters for the sampling of a refinery sweeps material. This was extremely heterogeneous: trying to sample it *in toto* would have produced unacceptably high standard deviations. Instead, the material was processed through a three stage procedure, with appropriate levels of sampling effort being applied to each of the resulting fractions.
- The work by H. Sichel mentioned previously could be considered an example of stratified sampling.

### Broader context

These comments, prompted by BG, have ranged well beyond the scope intended by BG which was correctness of samplers in the context of a sampling audit. For completeness, notes about the broader context adopted here are included below:

#### *Fit for purpose*

The level of effort expended on sampling might be expected to depend on the purpose of the sampling and related valuation activities. Purposes could be arranged in a hierarchy:

- Commercial transfer of materials from despatcher to receiver. This requires the highest level of effort at achieving correctness. In situations where a regular transfer occurs, and both a despatcher’s and a receiver’s valuation is made, some relief can be gained by adopting a cumulative monitoring approach.
- Internal transfers and reconciliations
- Process samples. Sometimes these may be usable for comparative purposes even though they may not be correct: the ideal situation would be that a certain sample had a known fixed bias relative to the sample of interest.

#### *Other valuation legs*

Valuation of materials depends on three legs: massing, sampling, and laboratory analysis. Moisture determination can be considered as part of the ‘massing’ leg, but it should be noted that the sampling for moisture, and even the laboratory analysis, can present particular problems.

### References


1. François-Bongarçon, D., and Gy, P. Critical aspects of sampling in mills and plants: a guide to understanding sampling audits. *Jnl. S. Afr. Inst. Min. Metall.*, vol. 102, No. 8.
2. Bartlett, H.E. Design of primary samplers for slurries in concentrators and statistical methods for measuring components of variance in sampling. *Jnl. S. Afr. Inst. Min. Metall.*, vol. 102, No. 8.◆


## CSC wins R3m LAN deal at BHP Billiton SA, Johannesburg*

Computer Sciences Corporation (NYSE:CSC) in South Africa has won a R3-million deal to project manage the re-engineering of the Local Area Network (LAN) in the Johannesburg office of international resources giant BHP Billiton.

The new broadband network will support the group’s growth strategy and facilitate faster and more content-rich communications with local and international operations. More than 500 users will be connected to the new network.

Internationally, CSC is a major provider of IT services to BHP Billiton, and this is the first project it will undertake for the resources group in South Africa.

The LAN deal, comprising new networking infrastructure and professional managed services, spans a four year period. Defining the technical specification of the network has already started and the first phase is due to give live in October.

Johan de Wit, IT manager for BHP Billiton SA says the LAN is being re-engineered because ‘current technology restricts business performance and growth. It is neither robust nor flexible. Our new LAN will accommodate future voice and video applications, but the immediate impact will be the speed with which information will be delivered to our desktops’.

CSC in South Africa’s project manager Mark Austin says the entire network is being re-designed. ‘It is not just an upgrade. We’re designing and implementing an infrastructure that will enable BHP Billiton SA to make full and efficient use of their applications now, and into the future. The network management services installed will enable us to monitor network performance from CSC’s data centre in Randburg.’

De Wit says CSC in South Africa was chosen after a rigorous selection process determined its team had good technical skills and easy access to the international expertise invested in the companies’ relationship. Competitive pricing and the quality of after-sales support contributed to CSC winning the deal. ◆


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# Safe, quick and clean—award winning machine*

A safe, rapid and environmentally friendly method of measuring coal density has won the Australian coal industry's prestigious ACARP research excellence award in coal preparation for 2002.

Developed by the University of Queensland's Julius Kruttschnitt Mineral Research Centre, the UltraSort JK Pycnometer supersedes a laboratory-based heavy liquid technique, and the associated health and chemical disposal risks posed by the old method.

JKMRC researchers Dr Geoff Lyman and Andrew Jonkers won the award for their pycnometer, a technical innovation resulting from the ACARP-funded 'Safe, Rapid Coal Washability Assessment' project.

The JKMRC's innovation was selected from 160 current projects administered by the Australian Coal Association Research Program for the Australian coal industry.

Mr Ross McKinnon, Executive Director of ACARP's management company Australian Coal Research Ltd, pointed out at the ACARP tenth anniversary function in Brisbane recently that a number of the awards for 2002 were given to groups working on the environmental impact of coal mining.

The award to the JKMRC was one such example where the use of organic heavy liquids for float-sink testing had caused increasing concern over potential health hazards.

'A lot of work has been done to find a non-toxic alternative,' Mr McKinnon said. 'The JKMRC has come up with an entirely new approach in which dry density of individual particles is determined by separate mass and volume measurements.'

Geoff Lyman accepted the ACARP award on behalf of the JKMRC and his colleague Andrew Jonkers.

'It's really quite a feather in the JKMRC's cap to be the originators of a project that has led to the successful commercial development of a machine to do this kind of analysis,' Dr Lyman said. 'Gas pycnometers have been around for a long time, but they are slow to use and operate, and there is no way you would consider putting thousands of particles through a conventional laboratory gas pycnometer.'

Dr Lyman explained that the new pycnometer has the capability of analysing 30 particles a minute, equating to the required 3000 particles in 100 minutes to get an accurate measure of the density or washability distribution.

Use of the instrument is at present confined to particles greater than four millimetres.

'It is now possible to put 3000 or so particles into the feed hopper of the machine, choose the density fractions into which the particles are to be stored, start the machine and come back an hour and a half later and collect the results.'

He said the speed of the new pycnometer is quite remarkable: 'Future models may work even faster'.

During his 28 years as researcher with the coal and minerals processing sector of the mining industry, Dr Lyman realized that one of the major problems in assessing gravity separation processes is an inability to rapidly and safely measure the density distribution of particles.

'For gravity processes, the density is the most important characterization of the mineral to be fed to the separation process,' he said.

'It is on the basis of a coal or mineral particle's density distribution that they are going to be separated, and this particle by particle density information is absolutely invaluable—it's critical to the whole gravity separation process.'

Dr Lyman said that while the pycnometer had been developed to eliminate the use of toxic heavy liquids in the analysis of coal samples, another beneficiary of the technology would be the mineral industry, particularly iron ore and manganese, and anywhere else that gravity processes were used.

'The development of a rapid computerized gas pycnometer for the determination of individual particle densities really marks a genuine breakthrough in laboratory instrumentation and analysis equipment for the mineral industry,' he said.

'Iron ore and non-coal users will now be capable of carrying out very quickly, rapidly and safely densimetric determinations on samples which have never really been possible before.'

Dr Lyman said it was an honour to share in the award: 'It's a great source of satisfaction to have an award from ACARP and the Australian Coal Association which have supported much of our work in the past'.

The pycnometer has subsequently been licensed for manufacture and sale to Sydney-based sorting machine company UltraSort Pty Ltd through the JKMRC's commercial subsidiary JKTech Pty Ltd.

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# De Beers returns Duggan Cronin copy negatives*

More than 2300 copy negatives from the renowned Duggan-Cronin Collection have been returned to the McGregor Museum after more than 25 years in protective storage in the De Beers archives in Kimberley. The Duggan-Cronin Collection is regarded as one of the world's most important ethnographic photographic records and collections of artefacts of the peoples of southern Africa.

'We have no information on when we actually acquired the copy negatives', says De Beers archivist Brenda Feder, 'but they have been in our archives for more than 25 years and are in very good condition. We are pleased to return them to the McGregor Museum which is now in a position to store them appropriately along with the originals'.

According to Dr Richard Liversidge, former director of the McGregor Museum, the copy negatives were made during the period 1965 to 1967 on the recommendation of photographic expert Dr A.D. Bensusan as a means of protecting the integrity of the original collection. Some of the copy negatives were given to De Beers for safekeeping.

Over the past four years De Beers and the Oppenheimer family have donated more than R1,2 million to the Duggan-Cronin Project, aimed primarily at 'saving' and conserving the Duggan-Cronin photo collection.

Alfred Martin Duggan-Cronin worked for De Beers between 1897 and 1932, initially as a compound guard and subsequently as a 'photo-copier' responsible for reproducing engineering blueprints and the like.

Attention to and impressed by the variety of cultures of the migrant workers Duggan-Cronin also realized how quickly such cultures were being eroded by the industrial environment and compound life of the mines. Following the Anglo-Boer War Duggan-Cronin bought his first camera and began recording his first 'native studies' using the mines and the mine dumps as backdrops. During WWI he served as a medical orderly and photographed the military campaigns in South West Africa and East Africa.

On his return to the mines in 1919, and encouraged by the then Director of the McGregor Museum, Dr Maria Wilman, Duggan-Cronin engaged in regular photographic expeditions during his annual leave, following the 'native' mineworkers into their home environments. Upon his retirement in 1932 he devoted all his time to photography. By 1939 he had travelled almost 80000 miles and accumulated more than 5000 photographs of the people, landscapes and homesteads of southern Africa. ◆

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**The South African Institute of Mining and Metallurgy**
*Founded in 1894*

## OBITUARY

| | | Date of Election | Date Deceased |
|---|---|---|---|
| E.A. Cole | Retired Member | 20 October 1969 | 22 August 2002 |
| R.H. Hummel | Associate | 19 July 1991 | 2002 |
| A. Marsh | Retired Fellow | 17 March 1969 | 3 March 2002 |

## De Beers and South African National Parks form a conservation partnership*

De Beers amd South African National Parks (SANParks), have today signed an agreement which will see the integration of parts of the De Beers-owned Venetia Limpopo Nature Reserve (VLNR) into the core of the proclaimed Vhembe/Dongola National Park, in the Limpopo province in South Africa. This follows the signing of a 'Heads of Agreement' in July 1999.

In addition to the company's own land, De Beers has also contributed about R10 million to Peace Parks Foundation (PPF), specifically to help fund the purchase of several other properties that will fall within the future park. In terms of the agreement, the South African National Parks will contractually manage the area while De Beers retains title to its own properties.

According to Nicky Oppenheimer, chairman of De Beers, 'The signing of the contract marks an important milestone in the development of the new National Park. De Beers is especially proud to say that this would not have been possible were it not for the discovery of diamonds at Venetia. This is another example of how responsible mining of a valuable resource can contribute to the economic, social and environmental sustainability of the area, the country and, hopefully one day, the region'.

It is hoped that the Vhembe/Dongola National Park will eventually form part of a Transfrontier Conservation Area, a nature reserve of almost 5 000 $km^2$ being proposed by South Africa, Botswana and Zimbabwe.

Speaking for SANParks, chairman of the Board, Murphy Morobe said, 'This major conservation area links three countries and will conserve and promote some of the most precious ecological, cultural and historical assets of the country. SANParks is grateful to De Beers for their contribution to the consolidation of the core and contractual areas.

The partnerships between De Beers, SANParks, PPF and adjoining private landowners as well as the commitment by all stakeholders have clearly contributed to the success of this project. ◆

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***Black Empowerment in the South African mining industry***
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**COLLOQUIUM**
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***Gravity concentrtion***
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**COLLOQUIUM**
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