Quality Management and “Sample DNA”, supporting a proactive and integrated reconciliation.

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ABSTRACT

Currently, F-Series Reconciliation is used in the mining industry to monitor the ability of the supply chain to transform geological resources/reserves into saleable products required for the market. The inputs currently used in reconciliation include the information/data from the tonnes (involving different types of weightometers) and grades (involving different sampling points in the value chain).

This current metric faces several challenges including: 1) calculations are performed under the assumption that the input data (tonnes and quality) is representative of the different stages of the production process (from ore to product); 2) actions in response to reconciliation outcomes could be considered “reactive”, because, given they are generally calculated once a month or quarter; any issues identified have already impacted the financial outcomes to the organization for the period.

From the perspective of sampling/data representivity, quality management programs (including Quality Assurance and Quality Control or QAQC) are expected to be implemented across the value chain. This involves assessments to be undertaken to determine the “quality” of their inputs and processes, depending on the requirements established in the processing chain (e.g. geoscience, production, processing, port, and marketing).

The challenge of the current stage is that the quality of the inputs supporting the productive process are assessed in isolation and sometimes at different levels of maturity on sampling & QAQC concepts understanding, which can impact business capacity to optimise production decisions due to “false sense of data confidence”.

This paper elaborates on how the quality of the production inputs (tonnes and quality) could be managed in integration across the value chain, by the implementation of a centralised Quality Management to monitor, standardise, and manage the representivity of the information from “ore in the ground” to a “saleable product”. In addition, this paper highlights and opens the discussion on how the “sample DNA” (grade per particle size distribution) can be monitored and reconciled across the value chain to establish pro-active warnings if gaps are determined between Grade Control Model vs Grade Feed (same “ore DNA”), or Processing Plant versus Port (same “product DNA”), for example. Also, this work discusses on how today’s sampling practices can impact the “sample DNA” and the assessment of future technological applications related.

INTRODUCTION - CONTEXT

There is a biased desire in the mining industry, and across the supply chain, focused on “data processing”: big efforts and financial resources are invested in the current situation to obtain the information “as soon as possible”, or preparing the future with sensors and/or technological applications providing “real time data”, aiming for optimising production decisions.

This desire now also includes the use of sophisticated statistical algorithms, such as machine learning or conditional simulations, that are more and more explored/used to address topics as “uncertainty” and “optimisations” to maximise the value of the geological resources and the business.

On a mining business/financial perspective, frequently the teams across the supply chain (from exploration to marketing) works in isolation, driven by individual and sometimes disconnected Key

Performance Indicators (KPIs) that creates a “siloed” way of working between teams, not considering that until the extraction stage (including geoscience, planning and mining operations teams) the business is working with “ore”, but our final customers are expecting (and agreed in a contract) a “product” with certain level of specifications (lump, fines, concentrate, cathodes, etc.), which is managed by processing, port and marketing teams. This financial perspective demands an integrated collaboration between the teams across the supply chain to ensure it delivers the expected specifications in the final products to maximise the value of the company **(FIG 1)**.

FIG 1 – Mining value chain showing the stages related to “ore” that requires to be integrated with the generation of final “products” delivered to the final customers and marketing.

One of the outcomes of this “data processing” approach ended in the calculation of a series of metrics that are used by the business to measure the “health in the supply chain” (Compliance to Plan, Reconciliation, Metallurgical Balance, etc.). F-Series Reconciliation is used to monitor the ability of the supply chain to transform geological resources/reserves into saleable products required for the market. The inputs currently used in reconciliation include the information/data from the tonnes (involving different types of weightometers) and grades (involving blastholes, sample stations and different sampling points in the value chain).

The main challenge of the current stage is that the quality of these inputs (especially the grade related) is normally just assumed as “fit for purpose”: they are assessed in isolation by different teams (geoscience, processing, port and marketing), sometimes at different levels of maturity on sampling and quality programs concepts (not standardised), and where operational duties are prioritised against the quality monitoring, reducing the ability of teams to monitor the information…all these situations increase the risk of organisations to operate under higher levels of risks for an unknown representiveness and quality data….however, these are the inputs used to calculate the F-Series Reconciliation outcomes and the other metrics in the business, and that’s the reason long reactive investigations are required in gaps over production results that results on tension between teams and financial losses **(FIG 2)**.

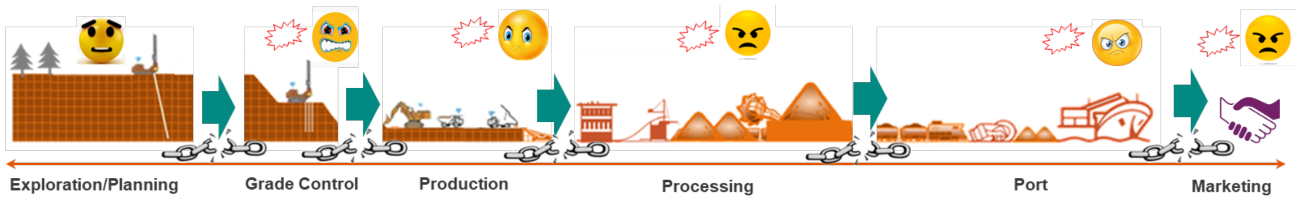

FIG 2 – Frequent disconnections within the mining value chain showing the tension between teams when gaps occur.

QUALITY MANAGEMENT

Quality Management (Dominguez, 2021) refers to the system providing the ability of organisations to quantify and monitor the quality/representiveness of the inputs used for production and financial decisions across the value chain, to consistently provide the products and services that meet internal and external customers, and regulatory requirements.

Quality Management (QMS) represents the evolution of normal Quality Programs (QAQC) toward a more integrated and standardised perspective, where the quality and representiveness of the main inputs (tonnes and grades) are proactively quantified, monitored and quickly addressed in deviations.

The main contribution for QMS is related to the quality quantification, which allow the business to assess and determine the risk/impact of potential deviations, and if further resources are required, the objective quantification will allow the development of business cases to get the budget required.

Current visual inspections, for example, being subjective, don't allow the quantification of the risk for the company and for this reason quality has been historically related to cost. However, through QM, historical costs can be replaced by opportunity costs which can be better communicated to decisions makers.
Why this is important? As example, Ralph Holmes (2021) quantified in US$23 M the potential value loss for just a 0.1 per cent Fe bias in an iron ore mine exporting in a year 250 Mt.

VISUAL INSPECTIONS VS QUALITY MANAGEMENT

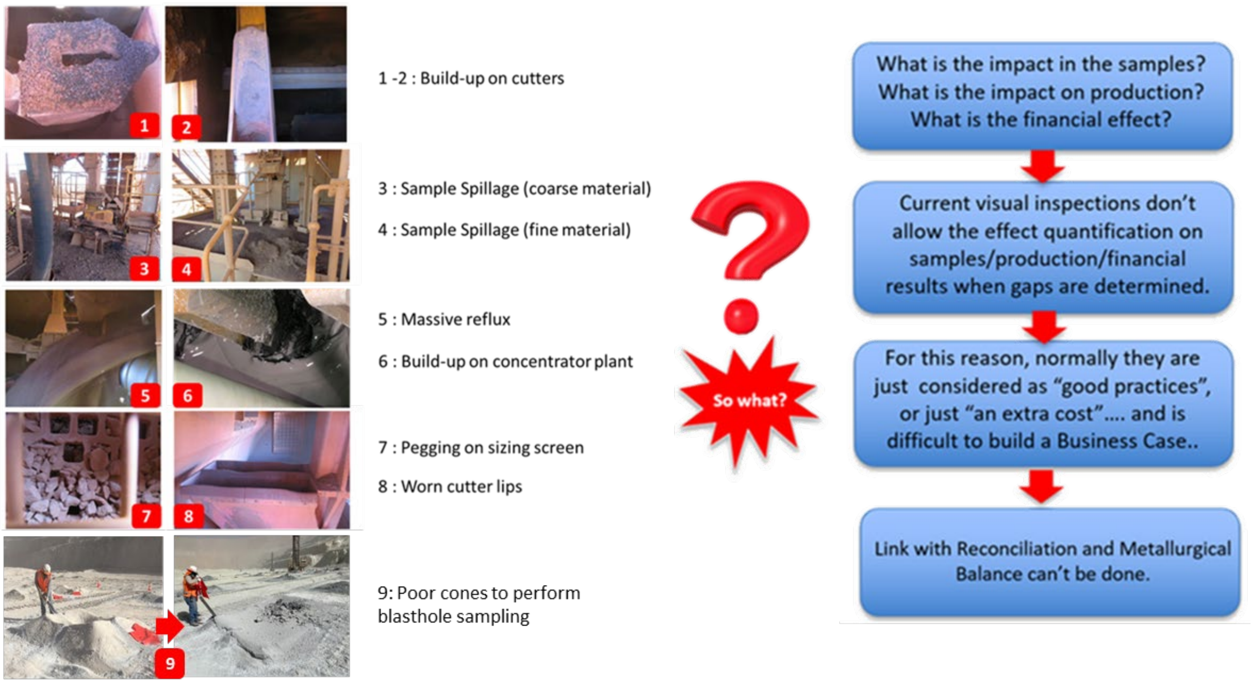

FIG 3 – Challenges visual inspections faced to quantify the impact of gaps.

Visual inspections are normally performed across the supply chain with the objective of determine gaps in the process **(FIG 3)**. Despite the enormous value, as an early warning when things are going wrong, its subjective nature impact the ability to translate on business risk, and the implementation of improvements are very hard to justify in the organisation because the gap that it is intended to be address can't be quantified resulting in the perception that quality is just a good practice or a cost.

QUALITY MANAGEMENT ON SAMPLING SUPPORTING RECONCILIATION

FIG 4A shows F2 monthly reconciliation results showing a consistent bias between the Feed Grade received at Processing Plant versus Grade Control Model. In addition, **FIG 4B** shows that the two sample stations supporting the production were also performing biased (SS1 is the most important sample station and process most of the production).

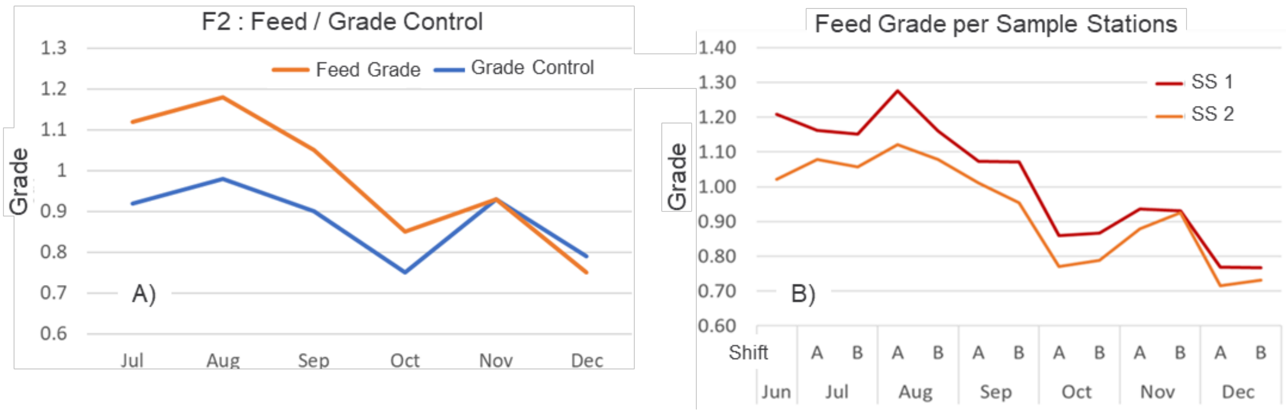

FIG 4 – A) Difference in grade between Feed Grade versus Garde Control impacting F2 reconciliation results. B) Difference in grade between the 2 sample stations collecting the feed grade information.

In the absent of a quantified quality, this difference in F2 generated big tension to the business, but also between teams: which information was right or wrong? But also, which sample station is right? Is blasthole sampling ok? **(FIG 5).**

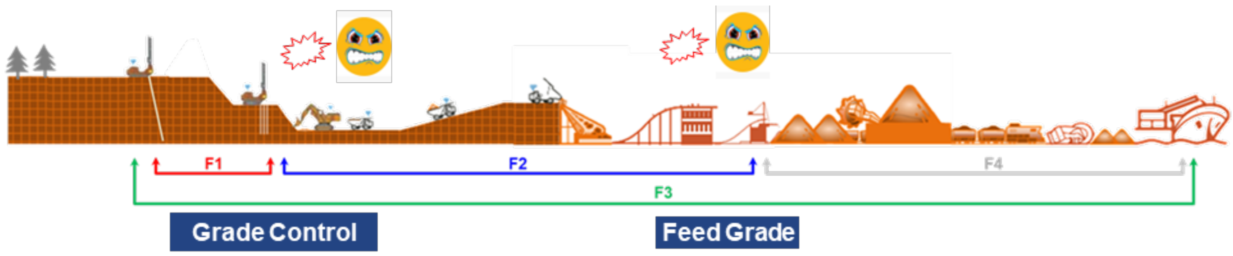

FIG 5 – Tension between Geoscience and Processing teams due to gaps in the F2 reconciliation results.

On a sampling perspective, it was well known in this commodity the grade distribution across the grainsize profile (Sample DNA – **FIG 6**): higher grades were located in the fine fractions of the samples (so by collecting more fines, the grade could be overestimated, or by collecting coarser fractions the grade could be underestimated).

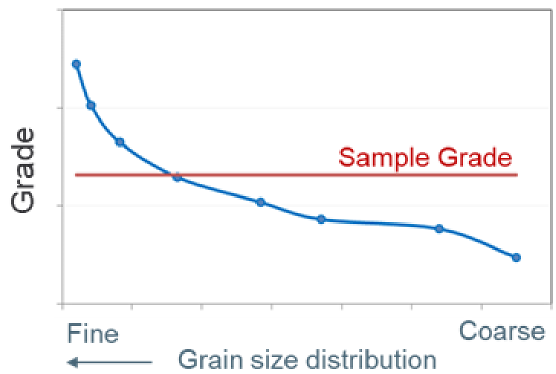

FIG 6 – Sample DNA – Grade per particle size distribution profile.

Bias tests are performed to assess and quantify potential levels of bias present on sample stations, normally located on processing plants and ports. In this process, a belt is stopped, and a representative reference sample is collected from the material on the belt (the lot). The belt is restarted, and next to the reference just collected, a normal sample going all through the sample station (primary cutter, secondary cutter, etc), is obtained by the sample plant. Both samples are analysed to determine if there is bias in the sample plant **(FIG 7)**.

FIG 7 – Examples collection of the reference sample from a conveyor belt during a Bias Test.

Bias tests performed in both sample stations indicated that the samples collected at Sample Station 1 were including more fine fractions than the material contained in the belt (reference), leading to an over-estimation of the grade. This trend helped to understand the source of the F2-reconciliation differences between Feed Grade and Grade Control. But, in addition, the samples collected from Sample Station 2 were containing coarser fractions than the reference, which underestimate of the grade….so both sample stations were biased, but in different directions (**FIG 8)**.

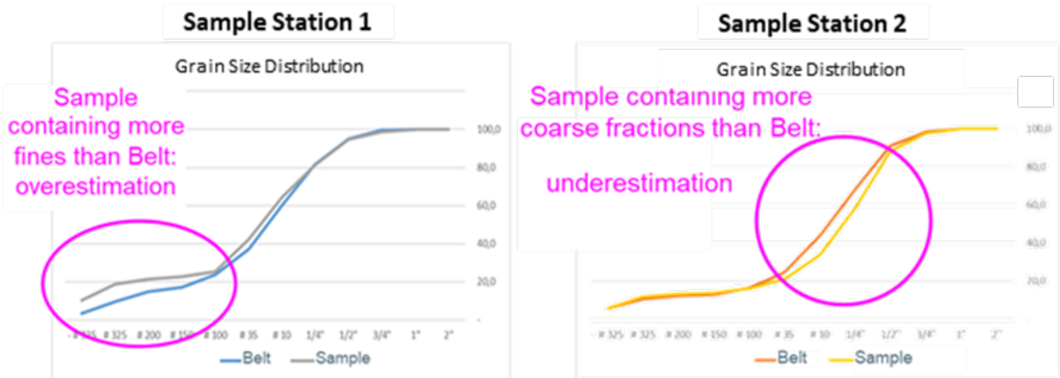

FIG 8 – Comparison for a cumulative grain size distribution between the sample and the belt reference for Sample Station 1 and Sample Station 2.

The quality quantification aimed by Quality Management is a critical requisite to manage the information across the supply chain, and it represents the evolution or expansion of the Quality Programs normally implemented in geoscience teams (as consequence of JORC Code 2012 requirements) through the entire value chain, including marketing.

In this example, a reactive reconciliation process took months to understand the source of the difference in the F2 value, and the quality quantification gave the answers on the source of the gap, but also in the impact for the business…this is QM spirit for a more objective and proactive approach!!

Finally, it needs to be highlighted that a condition where the quality/representiveness of the samples/data hasn't been quantified, the potential impact are not only be over current production results, the impact can be impacting the future, if new technology or real time data providers wanted to be trailed, because the technology needs current data to be calibrated….so there is a potential to calibrate the technology with non-representative data (Dominguez, 2019).

CONCLUSION

Quality Management (QMS) represents the evolution of normal Quality Programs (QAQC) toward a more integrated and standardised perspective, where the quality and representiveness of the main inputs (tonnes and grades) are proactively quantified, monitored and quickly addressed in deviations.

The implementation of Quality Management requires a holistic, integrated, standardised and an independent team monitoring and quantifying the quality of the main inputs used of F-Series Reconciliation, but also the other metrics used by the business (compliance to plan, metallurgical balance, etc).

Current visual inspections are not enough to manage the representiveness of the samples/data because its subjective nature and the impossibility of translating to a quantified impact or risk for the business.

The example provided highlights the importance for going from a current reactive subjective approach where the data is just assumed as “fit for purpose”, to a more proactive where the quality of the inputs are known and monitored, and decision are based on objective-technical information.

It is important to highlight that the absent of a quantified condition of the samples/data used not only will have an impact on current production decisions, but it also can also impact the implementation of new technology by using unknown quality data to be used on calibrations.

FINAL THOUGHTS

Any basic or sophisticated statistical analysis (machine learning or conditional simulations for example) will be very depending on the quality and representiveness of the samples behind the data. Quality Management is a pre-requisite to ensure representative data is used for further data processing.

REFERENCES

Dominguez, O, 2019. Applications for Portable XRF Analyzers. PDAC 2019. Toronto, Canada.

Dominguez, O, 2021. Quality Management (QM): The heart of the QAQC process, Spectroscopy World, vol 33(1), February 2021.

Holmes, R, 2021. Incorrect sampling practices always have significant economic consequences – and never more so than where tonnages are large, Spectroscopy Europe, vol 33, October 2021.

JORC, 2012. Australasian Code for Reporting of Exploration Results, Mineral Resources and Ore Reserves (The JORC Code) [online]. Available from: <http://www.jorc.org> (The Joint Ore Reserves Committee of The Australasian Institute of Mining and Metallurgy, Australian Institute of Geoscientists and Minerals Council of Australia).