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New Predictive Blasting Model Oriented to Optimum Production Planning

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Introduction

Blasting Objectives

(i) Maximizing the SAG mill throughput by providing it with the optimum feed size distribution

(ii) Optimizing the blast fragmentation and muckpile profile to maximize the productivity of load and haul operations

(iii) Minimizing orebody dilution and high wall damage due to blasting

(iv) Minimizing the operation cost of the whole production chain.

Introduction

Main Models

(i) Kuz-Ram

(ii) JKRMC (CZM, TCM)

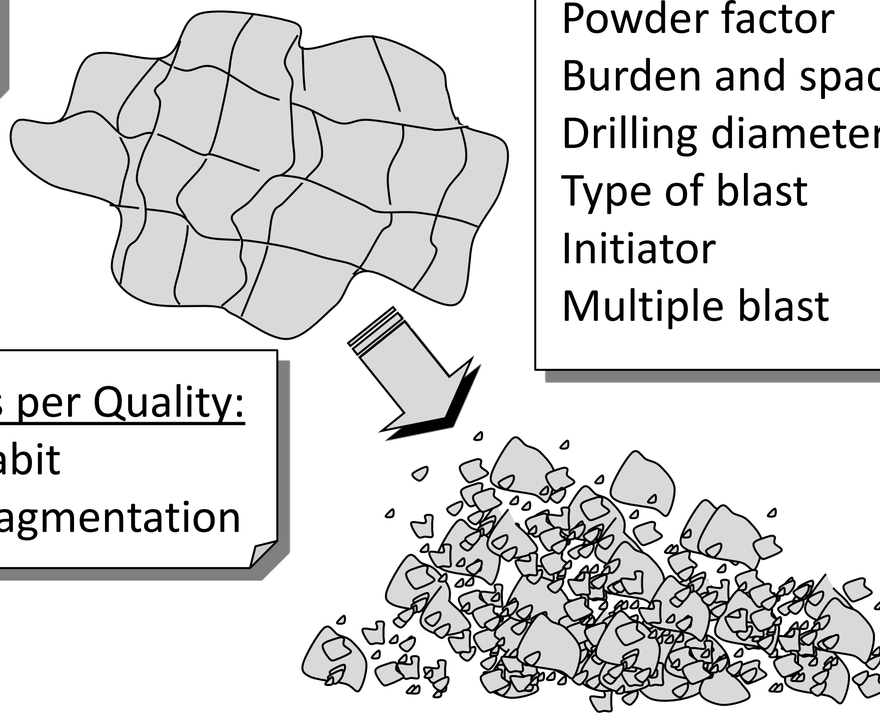
(iii) Swebrec

Model	Type
Kuz-Ram	Empirical, 3 basic equations
JKMRC: “The Crushed Zone Model”	Empirical, bimodal Kuz-Ram type
JKMRC: “The Two Component Model”	Empirical, bimodal Kuz-Ram type
Ouchterlony (Swebrec function)	Empirical, bimodal

Phenomenological Approach

<u>Mineral Variables:</u>
Tonnage
Blast area
Physical Quality

<u>Process Variables:</u>
Powder factor
Burden and spacing
Drilling diameter
Type of blast
Initiator
Multiple blast



<u>Internal Variables per Quality:</u>
Fragmentation habit
Specific rate of fragmentation

<u>Responses:</u>
ROM size profile
Energy consumption

Population Balance

$$\frac{d w_i(\bar{E})}{d\bar{E}} = -S_i^E\, w_i(\bar{E}) + \sum_{\substack{j=1 \\ i>1}}^{i-1} b_{ij} S_j^E\, w_j(\bar{E})$$

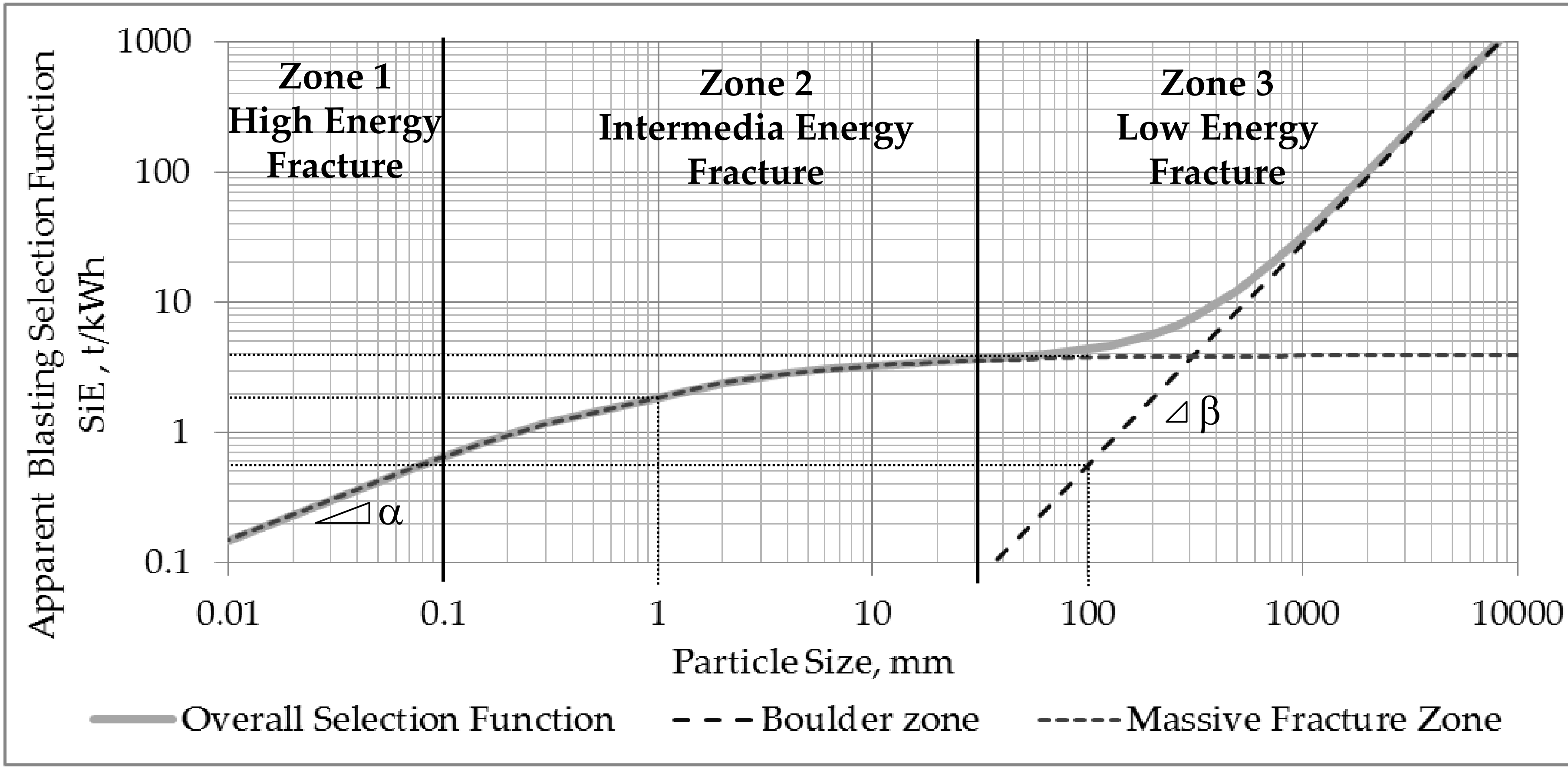
$$w_i(\bar{E}) = \sum_{j=1}^{i} a_{ij} e^{-S_j^E \bar{E}}$$

$$a_{ij} = \begin{cases} 0 & i<j \\ w_i(0) - \sum_{\substack{k=1 \\ i>1}}^{i-1} a_{ik} & i=j \\ \dfrac{1}{S_i^E - S_j^E} \sum_{k=j}^{i-1} S_k^E\, b_{ik}\, a_{kj} & i>j \end{cases}$$

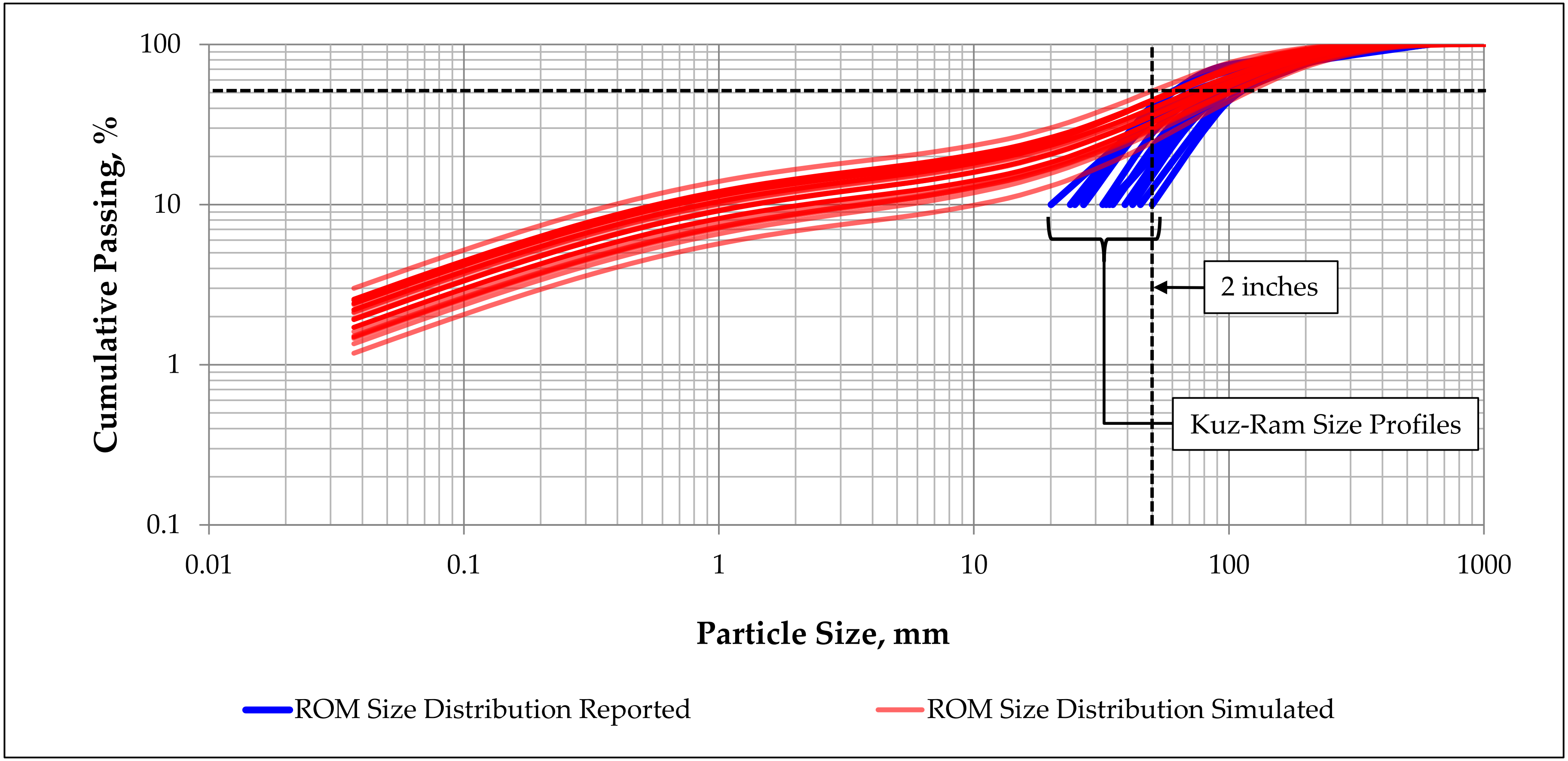
$$\frac{d R_i(\bar{E})}{d\bar{E}} = \sum_{\substack{j=1 \\ i>1}}^{i-1} B_{ij} S_j^E\, w_j(\bar{E}); \quad B_{ij} S_j \simeq S_i \quad \Rightarrow \quad P_i = 1 - \sum_k f_k \left(1 - F_i\right) \exp\left(-S_{ik}^E\, \bar{E}\right)$$

$$S_{ik}^E = \prod_i \left(\frac{p_i}{p_{i\,Ref}}\right)^{\varepsilon p_i} \left\{ a_k \left(\frac{x_i}{x_0}\right)^{\alpha_{1k}} \left(\frac{1}{1 + \left(\frac{x_i}{x_0}\right)^{\alpha_{1k}}}\right) + b_k \left(\frac{x_i}{x_1}\right)^{\beta_k} \right\}; \qquad \bar{E} = FC \times P_e$$

The Selection Function: Scale Up Criteria



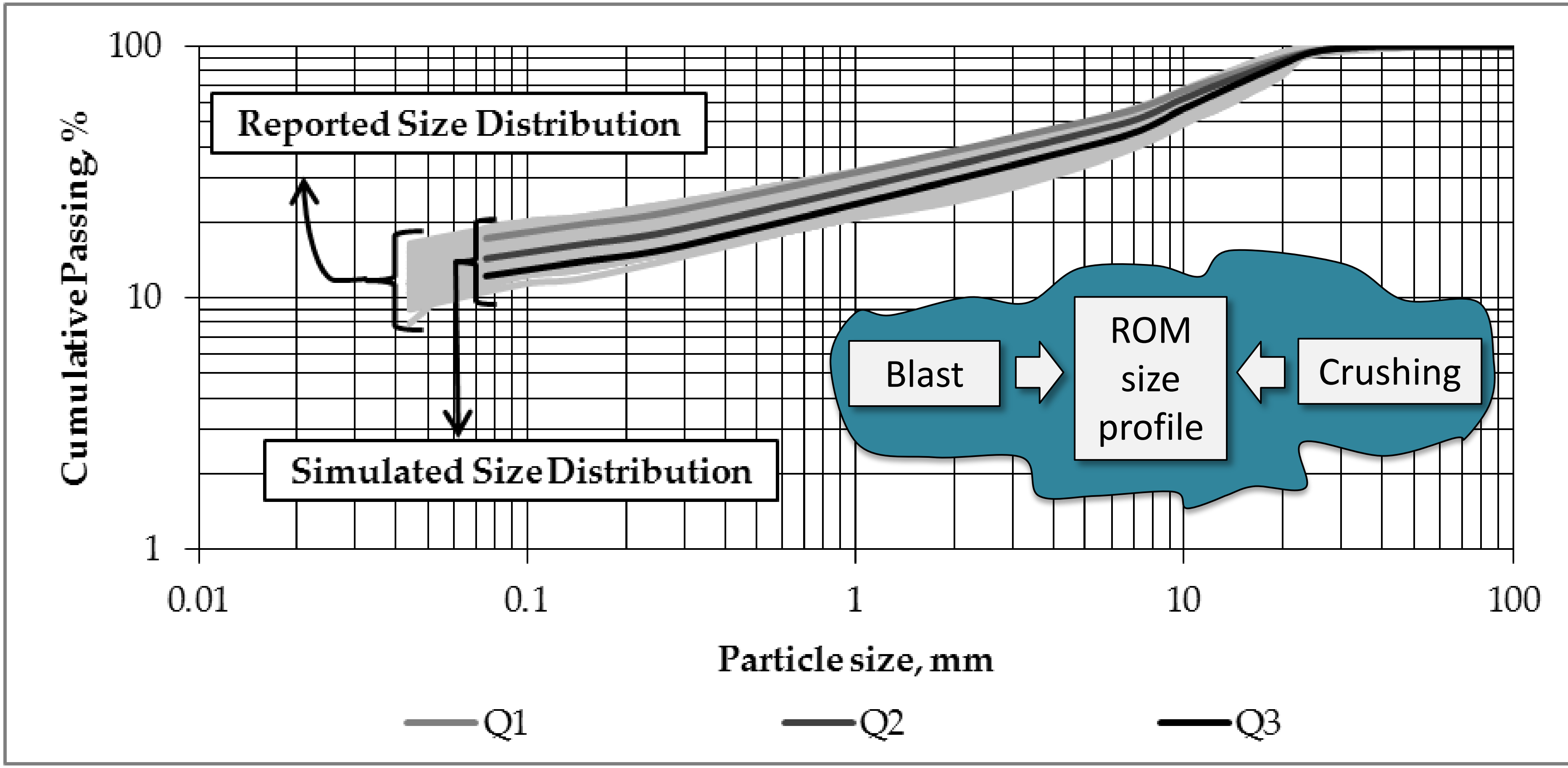
Typical ROM Particle Size Profile



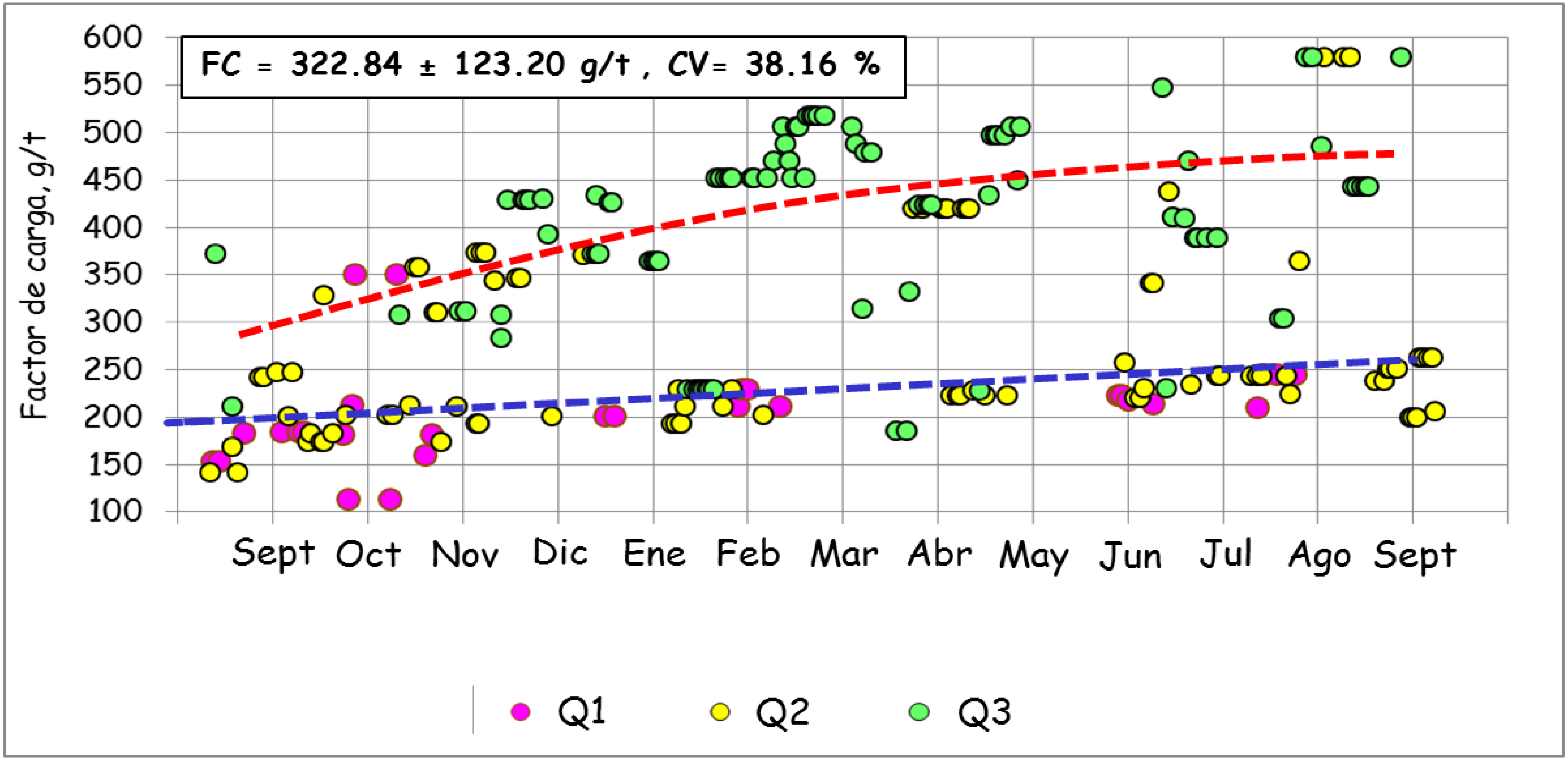
Applications

This blast simulation model has been successfully applied at CODELCO DGM, AMSA Antucoya, BHP Spence and CODELCO DRT, either for diagnosis, optimization or production planning purposes

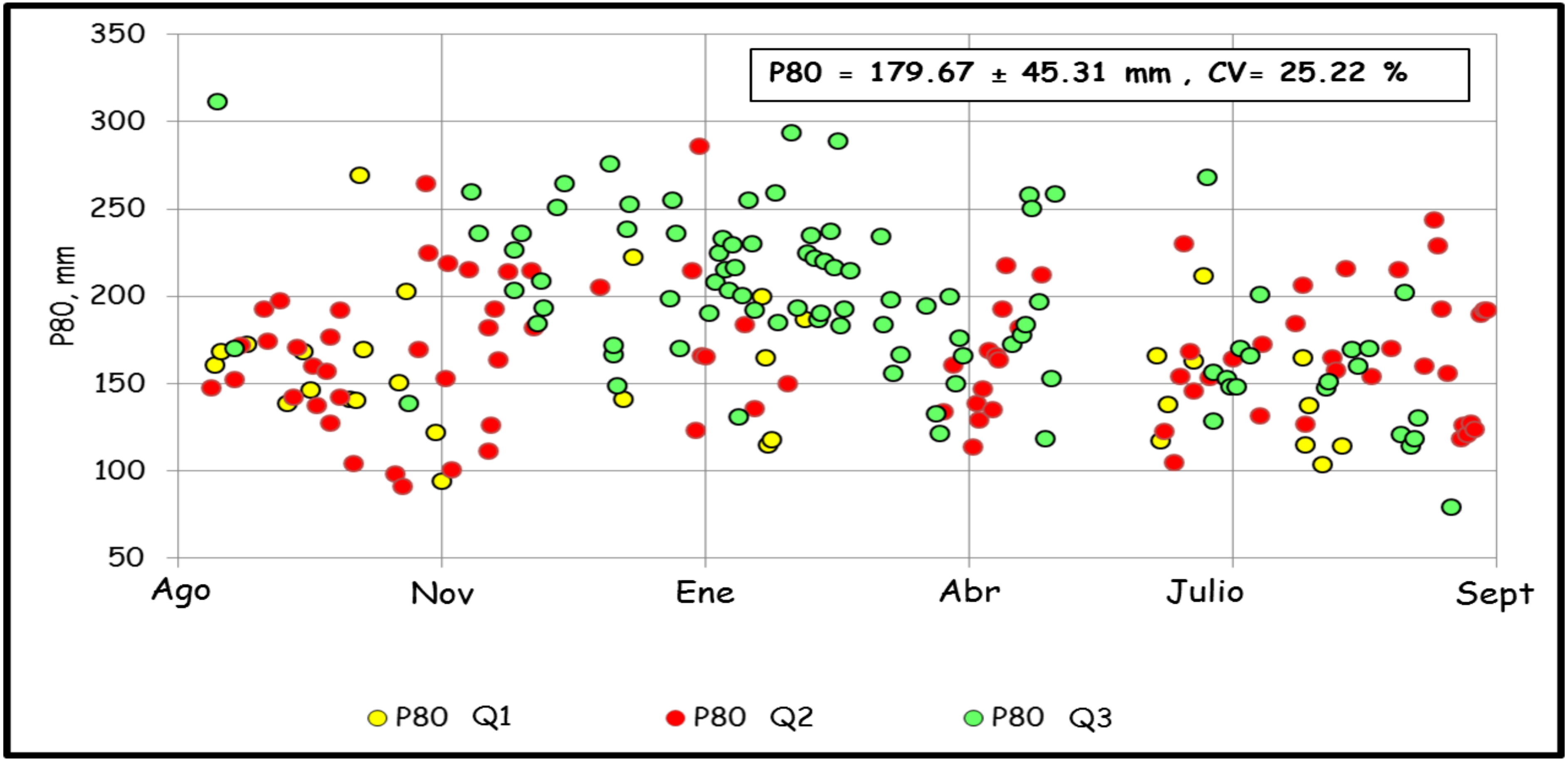
Inverse Simulation: Mine-Plant Matching



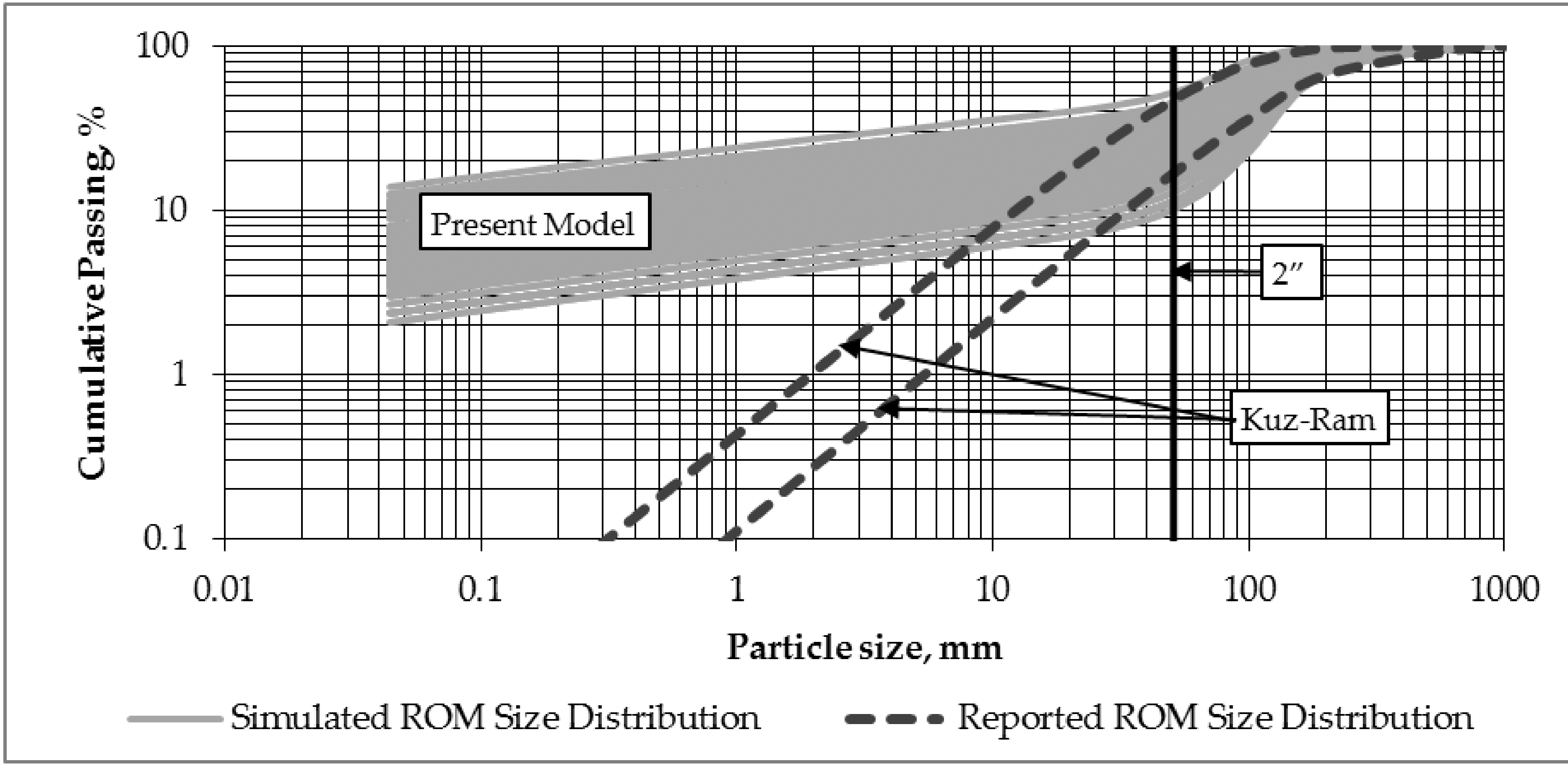
Blasting Auditing



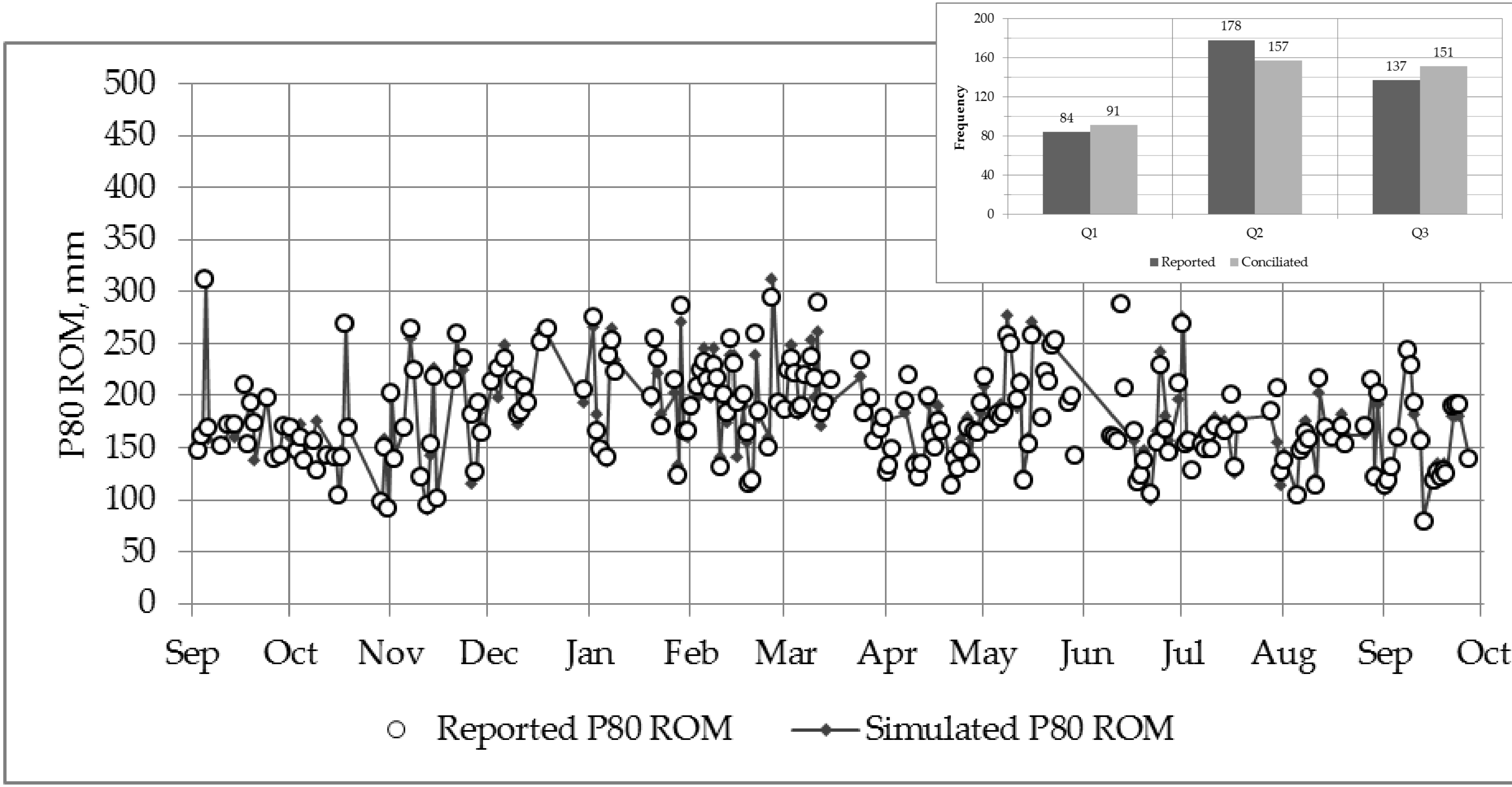
Blasting Auditing



Forecasting the Fines



Physical Quality Conciliation



Conclusions

A new phenomenological model to predict size distribution of blasted ores has been developed with clear advantages over the state of the art. It can be used for diagnosis, optimization and especially production planning issues.

Fragmented rocks in blasting usually follow a bimodal profile in log-log scale fairly well predicted by the present model.

Bimodal size distributions are attributed to a dual fragmentation mechanism. One driving to incomplete fracture of the coarse rocks and the other producing fines following a characteristic breakage pattern with root in the fractal genesis of the orebody.

The fines profile is correctly predicted by the phenomenological model. It drives to more fines compared to those estimated by the empirical standard models. A back-calculation procedure at the crushing and grinding plant supports the validity of the blast size-model estimations.

Finally, a method to forecast blasted muck size profiles is outlined.