Innovations for Sustainable Development of Mineral Industries

B.K.Sahu

Emeritus Professor for Life, Dept. of Earth Sciences, IIT Bombay, MUMBAI-400076, India

Abstract

Sustainable development insures conservation of ecology and environment including those of natural resources like minerals, water, and energy with simultaneous efficient economy for equitable social progress so that future generations do not face any disadvantages. Innovative but holistic approaches are necessary encompassing social, economic, and policy measures. We focus on sustainable development of mineral industries through use of statistical and computer based technologies. Statistics is most effective technology of 21st Century and, hence, it should be applied for currently low profiled mineral industry facing depletion of high-grade ores. Intensive exploration, optimal processes of mining, beneficiation and marketing using latest statistical technologies of optimization, risk minimization and sustainable growth are needed.

Marketable minerals occur at crustal shallow depths in rocks and ores which are heterogeneous solids comprising several (C>3) distinct homogeneous minerals and usually contain pore spaces. Statistically homogeneous samples can be obtained using the concept of representative elementary volume (REV). Unfortunately, measurements on REV samples, lead to fractional constituents (c; 0< c < 1) for each distinct mineral and sum of all these fractions become 1.0. The main drawbacks of such data are: pdf of mineral fractions are Binomial for major (> 10%) and minor (1- 10%) constituents which reduces to Poisson if the constituent is very small (trace amounts, <1%); pdfs are not Gaussian so statistical technology can be applied, and since data is not Fullrank, C, but (C-1); so, unique inverse does not exist and gives spurious negative correlations among these constituents to confound inferences. Using measure theory, a log(c/(1-c)) pre-transform of these fractional constituents eliminates all above drawbacks and makes the transformed random variables independent, so that univariate/multivariate/time-series methods are applicable(Sahu, 2003 and 2005).

We list a few innovative applications and examples where these statistical technologies are use:

EXPLORATION: (i) location of positive anomalies for further intensive studies; (ii) location of negative anomalies for acting as sinks of toxic elements/materials;(iii) identifying pathfinder elements/minerals using Factor Analysis and Canonical Correlation Analysis;(iv) feasibility of mining and of bidding new areas.; MINING: (i) Optimal mining (open pit vs underground); Underground is preferred for ecology preservation;(ii) 3D optimal mine plans using lowest minable assay and computation of risk factor;(iii)mine extensions in vertical/horizontal directions to be used when necessary; BENEFICIATION:(i)Lowest mineable assay and beneficiation system needed, (ii)locating high-grade ores for conservation and later blending of low-grade ores,(iii)waste management policies/decision; and MARKETING:(i)optimal classification ore grades,(ii)optimal marketing strategy,(iii)blending of low-grade ores in situ and lying in dumps.

Introduction:

Large-scale industrialization and urbanization with greater consumption of mineral and energy resources since the Industrial Revolution have greatly depleted high grade resources available at shallow depths of crust. Therefore, more intensive search for these finite resources is necessary at greater depths and for lower grades besides optimal mining, processing and marketing in order to maintain sustainable development of economy, society and to have higher national growth. Mineral resources include high-grade marketable ores and/or associated low-grade ores which require blending and/or beneficiation to market the products at profit.