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## Use of GIS in Mineral Resources of Ajmer District, Rajasthan

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**ABSTRACT:** There are several classification systems for the economic evaluation of mineral deposits worldwide. The most commonly used schemes base on the International Reporting Template,<sup>[1]</sup> developed by the CRIRSCO - Committee for Mineral Reserves International Reporting Standards, like the Australian Joint Ore Reserves Committee - JORC Code 2012,<sup>[2]</sup> the Pan-European Reserves & Resources Reporting Committee' – PERC Reporting Standard from 2016,<sup>[3]</sup> the Canadian Institute of Mining, Metallurgy and Petroleum - CIM classification<sup>[4]</sup> and the South African Code for the Reporting of Mineral Resources and Mineral Reserves (SAMREC).<sup>[5]</sup> A more detailed description of the historical development concerning reporting about mineral deposits can be found on the PERC web site.

**KEYWORDS:** mineral resources, international reporting template, standards, reserves, historical, GIS

### I. INTRODUCTION

In this study of Ajmer district, a 'Mineral Resource' is a concentration or occurrence of material of intrinsic economic interest in or on the earth's crust in such form, quality and quantity that there are reasonable prospects for eventual economic extraction.<sup>[7]</sup> Mineral Resources are further sub-divided, in order of increasing geological confidence, into inferred, indicated and measured as categories.[1,2,3]

Inferred Mineral Resource is the part of a mineral resource for which quantity, grade (or quality) and mineral content can be estimated with a low level of confidence. It is inferred from geological evidence and assumed but not verified geological or grade continuity. It is based on information gathered through appropriate techniques from locations such as outcrops, trenches, pits, workings and drill holes which may be of limited or uncertain quality and it is also reliability.

Indicated resources are simply economic mineral occurrences that have been sampled (from locations such as outcrops, trenches, pits and drill holes) to a point where an estimate has been made, at a reasonable level of confidence, of their contained metal, grade, tonnage, shape, densities, physical characteristics.[4,5]

Measured resources are indicated resources that have undergone enough further sampling that a 'competent person' (defined by the norms of the relevant mining code; usually a geologist) has declared them to be an acceptable estimate, at a high degree of confidence, of the grade (or quality), quantity, shape, densities, physical characteristics of the mineral occurrence.

The Canadian legislation (NI 43-101) concerning mineral projects within Canada appears to be similar to the CRIRSCO based reporting codes and standards.[6,7]

Since 1998 an 'International Framework Classification for Reserves and Resources - Solid Fuels and Mineral Commodities' is in development by the United Nations Economic Commission for Europe (UN-ECE).

Generally, the classification of mineral deposits bases on an increasing level of geological/mineralogical knowledge about a mineral deposit.<sup>[1]</sup>

According to the CRIRSCO International Reporting Template mineral deposits are classified as Mineral Resources or Mineral Reserves. Surface mining comprises 90% of the world's mineral tonnage output. Also called open

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pit mining, surface mining is removing minerals in formations that are at or near the surface. Ore retrieval is done by material removal from the land in its natural state. Surface mining often alters the land characteristics, shape, topography, and geological make-up.[8,9]

Surface mining involves quarrying which is excavating minerals by means of machinery such as cutting, cleaving, and breaking. Explosives are usually used to facilitate breakage. Hard rocks such as limestone, sand, gravel, and slate are generally quarried into a series of benches.

Strip mining is done on softer minerals such as clays and phosphate are removed through use of mechanical shovels, track dozers, and front end loaders. Softer coal seams can also be extracted this way.[10,11]

With placer mining, minerals can also be removed from the bottoms of lakes, rivers, streams, and even the ocean by dredge mining. In addition, in-situ mining can be done from the surface using dissolving agents on the ore body and retrieving the ore via pumping. The pumped material is then set to leach for further processing. Hydraulic mining is utilized in forms of water jets to wash away either overburden or the ore itself.<sup>[28]</sup>

In Ajmer district, Geographic Information System or GIS can be utilized in different fields in Geology such as; mineral and petroleum exploration, environmental studies, geological mapping and hydrogeological modeling, and others.[12,13] In mineral exploration GIS can be used to a set of characteristics of specific minerals deposition that might be used as a guide to similar deposits in the region. Loss of organized way and procedure for collecting, displaying, managing and combining various geologic spatial data and from different sources and scales which in turn make the operation of mineral exploration encountered with some difficulties. The datasets include bedrock and superficial geological maps, geophysical survey data, geochemistry of samples, and mineral occurrence data.[14,15] Also, a number of line features such as; structural features, fold axes and formation contacts, should be present. The GIS is the best management tool for collecting and integrating all these spatial data. So, the aim of this paper is to showing how the GIS serve mineral exploration companies by creating maps (2D and 3D) showing areas favorable for mineral to deposit, based on the distribution of known minerals occurrences, and how GIS can save time and money[16,17]

## II. DISCUSSION

In Ajmer district study, a Mineral Reserve is the economically mineable part of a Measured Mineral Resource and/or Indicated Mineral Resource.

Mineral Reserves are subdivided in order of increasing confidence into Probable Mineral Reserves or Proved Mineral Reserves.[18,19]

A Probable Mineral Reserve is the economically mineable part of an Indicated Mineral Resource, and in some circumstances, a Measured Mineral Resources. It includes diluting material and allowances for losses which may occur when the material is mined. A Probable Mineral Reserve has a lower level of confidence than a Proved Mineral Reserve but is of sufficient quality to serve as the basis for decision on the development of deposit.

A Proved Mineral Reserve is the economically mineable part of a Measured Mineral Resource. It includes diluting materials and allowances for losses which occur when the material is mined.[20,21,22]

A Proved Mineral Reserve represents the highest confidence category of Mineral Reserve estimate. It implies a high degree of confidence in the geological factors and a high degree of confidence in the Modifying Factors. The style of mineralization or other factors could mean that Proved Mineral Reserves are not achievable in some deposits.

Generally the conversion of Mineral Resources into Mineral Reserves requires the application of various Modifying Factors, including, but not restricted to:

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- mining factors;
- mineral processing / ore dressing related factors;
- metallurgical factors;
- infrastructure factors;
- economic factors;
- marketing factors;
- legal factors;[23,24]
- ESG factors: Environmental, Social (including Health and Safety) and Governance<sup>[5]</sup>

In Ajmer district area, the Mineral exploration is the process of finding ores (commercially viable concentrations of minerals) to mine. Mineral exploration is a much more intensive, organized, involved, and professional process than mineral prospecting, though it does frequently use the services of prospecting.

The first stage of mining consists of the processes of finding and exploring a mineral deposit. In the following first stage of mineral exploration, geologists and surveyors play a prominent role in the necessary pre-feasibility study of the possible mining operation. Mineral exploration and estimation of the reserve through various prospecting methods are carried out to determine the method and type of mining required in addition to the profitability conditions[25,26]

Once a mineral discovery has been made, and has been determined to be of sufficient economic quality to mine, mining engineers will then work on developing a plan to mine this effectively and efficiently.[27,28]

The discovery can be made from the research of mineral maps, academic geological reports or local, state, and national geological reports. Other sources of information include property essays and local word of mouth. Mineral research usually includes the sampling and analysis of sediments, soil and drill-core. Soil sampling and analysis is one of the most popular mineral exploration tools.<sup>[21][22]</sup> Common tools include satellite and airborne photographs or airborne geophysics, including magnetometric and gamma-spectrometric maps.<sup>[23]</sup> Unless the mineral exploration is done on public property, the owners of the property may play a significant role in the exploration process, and might be the original discoverer of the mineral deposit[29,30]

After a prospective mineral is located, the mining geologist and/or mining engineer then determines the ore properties. This may involve a chemical analysis of the ore to determine the composition of the sample. Once the mineral properties are identified, the next step is determining the quantity of the ore. This involves determining the extent of the deposit as well as the purity of the ore.<sup>[25]</sup> The geologist drills additional core samples to find the limits of the deposit or seam and calculates the quantity of valuable material present in the deposit. Once the mineral identification and reserve amount are reasonably determined, the next step is to determine the feasibility of recovering the mineral deposit.[31,32] A preliminary study shortly after the discovery of the deposit examines the market conditions such as the supply and demand of the mineral, the amount of ore needed to be moved to recover a certain quantity of that mineral as well as analysis of the cost associated with the operation. This pre-feasibility study determines whether the mining project is likely to be profitable; if it is then a more in-depth analysis of the deposit is undertaken. After the full extent of the ore body is known and has been examined by engineers, the feasibility study examines the cost of initial capital investment, methods of extraction, the cost of operation, an estimated length of time to payback, the gross revenue and net profit margin,[33,34] any possible resale price of the land, the total life of the reserve, the total value of the reserve, investment in future projects, and the property owner or owners' contract. In addition, environmental impact, reclamation, possible legal ramifications and all government permitting are considered.<sup>[26][27]</sup> These steps of analysis determine whether the mining company should proceed with the extraction of the minerals or whether the project should be abandoned. The mining company may decide to sell the rights to the reserve to a third party rather than develop it themselves, or the decision to proceed with extraction may be postponed indefinitely until market conditions become favourable. Mining engineers working in an established mine may work as an engineer for operations improvement, further mineral exploration, and operation capitalization by determining where in the mine to add equipment and personnel. The engineer may also work in supervision and management, or as an equipment and mineral

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salesperson. In addition to engineering and operations, the mining engineer may work as an environmental, health and safety manager or design engineer.[35,36]

The act of mining required different methods of extraction depending on the mineralogy, geology, and location of the resources. Characteristics such as mineral hardness, the mineral stratification, and access to that mineral will determine the method of extraction.

Generally, mining is either done from the surface or underground. Mining can also occur with both surface and underground operations taking place on the same reserve. Mining activity varies as to what method is employed to remove the mineral. The Geographic Information System (GIS)[37,38] now is used in many fields among such as agriculture and land use, forestry and wildlife management, monitoring of desertification, archaeology, city planning, municipal applications and geology. The applications of GIS in geology are very broad and diverse, but here we'll focus in GIS application to serve mineral exploration. The process of mineral exploration composed of several stages which starts with small scale and develops into larger scale. In every stage, geological, topographical, geophysical, geochemical data are collected, processed and integrated.[39,40] Then, after finishing every stage produced mineral potential map and the study area becomes smaller. Mineral exploration companies deal with various types of data sources to explore for minerals deposits. The types of data vary from geological maps, multispectral satellite images, and geophysical images to databases in different formats.[41,42]

### III. RESULTS

In the study of Ajmer district, the GIS also can be used to generate a mineral potential map, in the absence of comprehensive systematic mineral exploration programs, it is important to develop alternative methodologies of mineral potential classification[43,44]. Then, it's possible to use spatial data that are relevant to mineral potential such as; lithology and topography, which are available for most areas. The importance of such data can be realized by their incorporation in GIS (Bonham-Carter, 1994). Then it is important to add exploration criteria. Those criteria provided by conceptual mineral deposit models are invaluable bases for the generation of mineral potential information. GIS can be useful in many stages of mineral exploration processes: data acquisition, storage, manipulate, and reporting. Its possible now to the geologists gain the field data electronically that by using Global Positioning System (GPS) receivers. [45,46]The Internet also can be act as a source of data sets which can be downloaded directly from it. All these data types can be combined, integrated, and analyzed using GIS. GIS can easily integrate with other specific programs for image and geophysical data processing. So, Raster images such as satellite imagery or geophysical images can be displayed in GIS and overlaid with vector data such as geology, faults, and geochemical samples.[47,48]

Geologists can apply GIS in mining and mineral exploration to present data in an integrated platform by using traditional cross-sections and graphical strip logs in conjunction with planning map views. In mineral exploration geologists deal with various types and sources of data to explore for new economical mineral deposits. The data sources vary from geological maps, multispectral satellite images, and hyper-spectral airborne and geophysical images to data in many formats. GIS is the best platform to bring all these data together in a geologist's computer and deliver fruitful outcomes. GIS is now able to assist geologists in many fields related to their activities such as; data acquisition, administration, manipulate, and evaluating the whole operation. [49,50,51]Now, the geologists are able to collect field data electronically by using Global Positioning System (GPS) receivers and ArcPad. Also, we can download other data from the Internet. All types of geological datasets such as; geological maps, geochemical logs, geophysical images, boreholes, radius measurements, and mineral accumulations, can be shown, revealed, and interpreted immediately using GIS. On the other hand, Roads, pipelines, ramps, electric lines, and other mining requirements change usually. The operators and engineer's crew can use GIS for the applications of production plans.[52,53] For example, they keep tracking the available basement and combining it with the mining plan and pure modeling can be done using GIS. Fortunately, GIS may used to combine survey data with complete models or mining planning information which result from various mine software groups such as GeolSoft, Surpac Range, Mine Sight, Vulcan, and Mining Visualization System (MVS). Many of mine data comprising money and evaluate information has some source of spatial feature that

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may easily displayed in maps forms. Managers and economist are using GIS in their evaluation of corporate and competitor assets. Mining companies also use GIS to actively monitor the environmental impacts that may be caused by their activities and conduct reclamation.[54,55]

## IV. CONCLUSIONS

In Ajmer district study, the GIS in mineral exploration can be time effective in order to the following factors: - Combine data and datasets from different sources with ease. - Link directly from modeling software such as; MapInfo and Leapfrog to database of results ensuring the most recent assay information from analytical testing are included. - Model quickly and easily in 3D the resource you are exploring from both historical and modern drillhole data stored in your database.[56,57] - This method of modeling saves digitizing many different features to be included in the model as it can be interpolated from the drillhole data by the system. On the other hand, GIS can save money and decrease the regular cost to explore for minerals and this due to these reasons: - Fewer hours spent digitizing to incorporate data into models. - Variety of GIS analysis methods on quantitative and raster data to look for anomalous areas. - The ability to capture old data of different types and view/analyze as compatible layers. Some of this data would only previously have been examined in paper formats. [58,59]- Ability to utilize free historical and modern data in current projects - there is a wealth of mineral exploration resources available on the web for free which can be utilized in the search for ore bodies: historical geological maps, satellite imagery, geophysical data and geochemical assay results data for the exploration target area in question are published freely on the internet. - Using GIS in mineral exploration encourages a more efficient use of already existing data which is cost effective. Exploration costs are rising –exploration drilling can be expensive and the rate of discovery of large world-class ore bodies is decreasing. However, re-analysis of existing data – both modern and historical, through GIS modeling e.g. through 3D modeling, allows for more targeted, cost effective exploration drilling.[60]

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