

Importance of Methods of Selection in the Geosciences Studies and Exploration

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Abstract

Selection of methods of study in geosciences and natural resources exploration has always been a concern for geosciences communities and industries. Financial cost and effectiveness of the methods are the most important issues. Additionally, integration between different methods and their application order are very essential to reach the best cost effectiveness and optimization. Methods such as remote sensing, mapping, various geophysical and geochemical surveys, and drilling are among the methods that were used for long time. Those methods were also integrated, recently, with more sophisticated and advanced techniques such as petro-physics, and wireline logs analysis in hydrocarbon industry, and organic bound and electro-geochemical behavior in minerals studies. To optimize the cost and efficiently utilize the resources careful selection of applied method is essential. Moreover, the phase that selected method will be used needs to be clearly defined and justified. The careful selection of specific method should be based on the needs and targeted results. Recently available free and low cost methods and tools should also be considered as a substitute for the higher cost conventional ones. New tools such as Google Earth, DEM, LIDAR and GIS can be used very effectively in revealing information that used to be obtained by more costly methods such as mapping and field surveys.

This paper highlights the importance of selecting the different methods for geosciences studies and exploration. The paper emphasizes the fact that selecting the method and utilizing it in the exact phase will help in reaching the right decision and obtaining results with low cost. Moreover, the recent available free or low cost techniques should also be considered in the geosciences studies in place of traditional high cost methods.

Introduction

Geological studies are very important for human being lives. They involve studies and researches related to atmosphere, oceans, land, energy, natural resources, mineral, climate change, natural hazards, and ecosystem structures and functions, and other issues related to Earth [1]. As stated in the USGS report (Geology for changing world 2010-2020) "The science of geology has the power to help us understand the processes that link the physical and biological world so that we can model and forecast changes in the system". Based on this importance of Earth Sciences, the USGS [1] defined six goals that should be considered in the future planning and strategy. Those goals encompass all aspects of geosciences studies and / or related to Earth systems in general [1]. They include but not limited to understanding of the Earth surface and climatic processes and anticipate their effects on ecosystem and health. Other important goals are the management of natural resources globally, and increase of the awareness about the geological and environmental hazards [1]. For those goals to be achieved advanced technologies are needed together with effective knowledge of data acquiring, analyzing and interpreting. The suggested goals of USGS [1] and the emphasis on effective data acquisition and analyzes required a careful and critical selection of methods of studies, (the topic of this article). This article attempts to define the different types of geological studies and factors that might affect the selection of study's method. A triangular model is suggested for those factors. And five steps are also suggested to be followed in any geologic methods' selection.

Types of Geologic Studies

Geological studies can be divided into two types; studies that are industrial oriented and studies that are of academic concern. The former include basically projects and (R&D) research and development studies. The project studies normally confined to the

project needs and very much tied to the fund and needed results. Whereas, the R&D studies might exceed the limit of projects need and extend to problem solving and future forecasted needed outcomes or methods. The academically directed studies can be laid in three categories; basic, applied and theses and dissertations researches. Additionally, the academically oriented studies are based on needs and necessity depends on available resources and always considers the local available tools first. The cost of analysis and tools use is not normally a major factor if supported and made available. In comparison, the industrial studies (either in exploration or exploitation stages) are mainly based on project needs and the future forecasted necessity requirements. In this type of studies the cost factor is very crucial and important. However, it is project driven and spending might be higher than the academic studies. Moreover, the analyses might not be limited to the available tools and resources and can consider tools where ever they are if needed.

Motivation of the Topic

The thoughts in this article were developed through work experiences in both industry and academy. The previous experience in mineral exploration laid to an observation that in some occasion stages of exploration was not followed systematically and higher level tools were used before the basic ones. Such example is very

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clear when drilling is applied even before basic geophysical techniques. This jump in applying higher cost tool before much cheaper ones is not only wasting of resources, but also may lead to a wrong interpretation. Another observation noticed in academic particularly through the supervision of several MS theses and PhD dissertations. Students normally select methods that are not needed for the research. Additionally, conduct higher level and costly analytical methods, although results can be obtained from low level less cost tools. Such an example is selecting X-Ray Diffraction or X-Ray Fluorescence or even Electron Microscopy to obtain information from petrographic study.

Factors controlling method's selection

Considering the previous discussion and observations, the two types of geologic studies (industrial and academic) is mainly controlled by three factors; objectives of study, the timeframe of the project and the available fund (Figure 1).

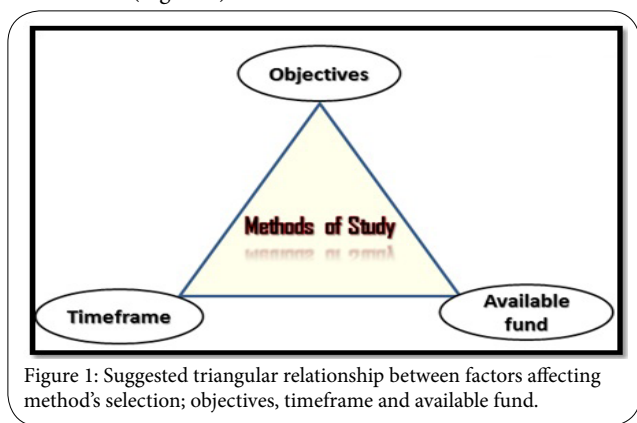


Figure 1: Suggested triangular relationship between factors affecting method's selection; objectives, timeframe and available fund.

Objectives Effect on Methods' Selection

Objectives of any studies are normally the essential steering for studies' tool requirements and used methods. They also control the fund and cost needs. If, for example, the study is in its initial stages (reconnaissance level) low cost methods and less advanced tools should be considered. However, if the objectives are of detail nature and advanced stage of study the higher cost tools and methods will be enforced. Example of reconnaissance level study is geologic mapping for a large size area. In such study satellite images and free Google Earth can be used very efficiently over field visits that required higher cost and fund. Additionally, the effective use of more costly methods and /or tools is also needs to be carefully selected and justified in detailed study.

Fund Effect on Methods' Selection

Fund is an important factor in selecting methods of study. The low available fund will have great influence on the direction of the research. As a matter of fact, the low fund might even change the objectives and force using less costly methods. An example of such is when rock analysis is needed low cost methods such petrographic and mass spectrometry might be selected over XRF. The limited available fund might be an obstacle to conduct detailed research and/or reach an in depth conclusion. Nevertheless, low budget may force utilization of available resources and tools more efficiently. In contrary, surplus of fund may encourage misuses of resources and allow conducting analyses that are not really needed for the project as results may be obtained with less cost tools and methods.

Timeframe Effect on Methods' Selection

Time allocated to any project is an important factor that even can affects the methods of study. Fast needed results will force selecting less sophisticated tools of analyses that don't require long time. In spite of the fact that precise results demands such tools. Therefore, limited time available force selecting fast results methods over the longer time needed ones. This issue needs to be considered well in the planning stage of the project to enable an efficient time schedule.

The Observations Rational

Based on the above remarks, nature and stages of study is controlling the methods selection (reconnaissance versus advanced exploration or production). Objective of study is an essential pace for selecting the method/s of study. Budget and available funds sometimes force cheaper and semi quantities methods over highly cost detail ones. Time allocated for the project is an important factor that influences the methods and tools selection. An important note is that if all methods and tools are available and budget is sufficient a wise decision should be taken based on real need.

In the view of this subject and considering the above discussions, selecting of methods and tools should be considered in the planning stage of the project/study. The selection of methods should consider the study objectives, its type or stage, the expected outcomes, the available resources, the allocated budget and fund and the timeframe.

A Case Study

An example of using two method of studies on an area and obtaining almost the same result is the determination of the Dammam dome fractures pattern and its relationship to the doming process. The dome is located in the eastern part of Saudi Arabia and has an anticlinal structure with a core excavated by erosion with a major axis trending N30-40W and covering an area of about 60 sq. mile. It hosts the first oil discovery of Saudi Arabia (Dammam-7). The rocks exposed within the dome are gently dipping (in all directions) of Tertiary age limestone rocks covered with Quaternary deposits. Results were obtained by using GIS and remote-sensing technique [2], and by field studies [3]. In the first approach lineaments were traced and interpreted using Satellite image (Google-Earth) and GIS techniques. Whereas, fractures characterization measurement, and classification were conducted in the field to determine the second result [2]. Trends of lineaments (from Google-Earth) and fractures (from the field) were very compatible. Moreover, the resulted patterns of both features obtained from the two methods indicated that fractures and lineaments are a result of the doming process. In addition, the trends of both features within different parts of the dome reflect specific stress generated within the rock units due doming. The field study is more costly and needs more effort and resources compared to the lineaments study. Although both studies provided a compatible results the field study was needed for ground-truthing. However, general studies of similar nature and for fast and semi-quantitative result only lineament approach can be utilized.

Suggested steps for methods' selection

This article suggests five steps that should be taken and considered before implementing any study (Figure 2). Those steps start with careful analysis of the project objectives to enable precise planning. The analysis of objectives will provide knowledge about the needed methods and tools. The importance of methods needed and level

of study will allow better definition and search for tools and cost estimation. Selecting the suitable methods should fit with the allocated budget and the timeframe of the project (Figure 2). In the project implementation local and available methods and tools should be considered first. However, if different types of tools and sophisticated methods are accessible and available doesn't mean they should be used if the results can be obtained from less cost and sophistication. This issue is normally noticed in academic institutions, where students tend to use all available instruments even if their projects not necessarily need them.

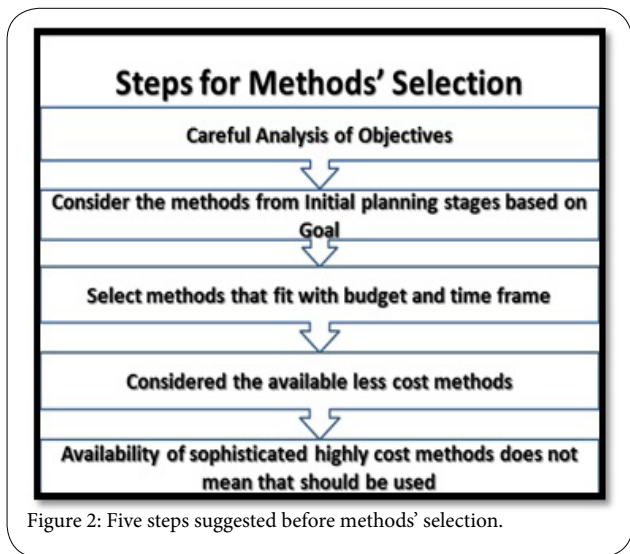


Figure 2: Five steps suggested before methods' selection.

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Final Remarks

Geosciences became an important and crucial subject with the world-wide advancement, development and civilization. Increase needs for natural resources and continual exhausting of them, geotechnical and geohazard problems, and many others issues are of concern. This matter triggers the USGS to establish a vision for changing and six goals were set to achieve this vision. One of those goals is related to data acquisition, interpretation and communication "Apply the Most Advanced Technologies and Best Practices To Effectively Acquire, Analyze, and Communicate Our Data and Knowledge". Acquiring effective data is achieved through the selection of suitable and appropriate methods that are cost effective and efficient. Selection of methods' in geosciences studies, as in other scientific studies, is an important and crucial issue. It will affect the result and outcomes if not selected well. However, there are several factors that might control the methods' selection among them are the objectives of study, the available fund and timeframe of the project. Additionally, those elements might force the use of specific methods and tools and utilization of available resources efficiently. This study emphasizes the fact that planning of methods' selection should be taken place in the initial stages of the project. It also suggests five steps that need to be considered in selecting methods and or tools of study. Those steps start with careful analysis for the objectives, consider the low cost and available methods first, and avoid using methods or tools just because of their accessibility and availability.

Competing Interests

The author(s) declare that they have no competing interests