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EVALUATION OF THE ORIGIN OF GROUNDWATER IN THE SARCHESHMEH COPPER MINE AREA

BY

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June 2013

بسم الله الرحمن الرحيم

Declaration

I herewith declare that I autonomously carried out the PhD thesis entitled "Evaluation of the Origin of Groundwater in the Sarcheshmeh Copper Mine Area". I undertake that this is a presentation of my original research work and wherever contributions of others are involved, every effort is made to indicate this clearly, with due reference to the literature, and acknowledgement of collaborative research and discussions.

Hassan Sahraei Parizi

June, 2, 2013

IN THE NAME OF GOD

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THESIS

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For Freshteh, Sina and Saba

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ABSTRACT

EVALUATION OF THE ORIGIN OF GROUNDWATER IN THE SARCHESHMEH COPPER MINE AREA

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The inflow of groundwater to the pit is the consequence of mining below water table. Wet working encounters the mining industry with many difficulties and hazards, the most important of which are; increase of drilling and blasting costs, difficulties in ore handling and crushing, decrease of machinery life, slopes instability, degradation of water quality and environmental problems. Therefore the management of groundwater resources and planning of appropriate dewatering systems are imperative requirements for the safe and cost effective mining below water table. Adequate management of groundwater resources and controlling groundwater inflows to the mine cuttings require good understanding of the sources of recharge and the major groundwater flow paths.

In the present research, the source of recharge and the flow paths of groundwater in the Sarcheshmeh copper mine, which is the largest copper deposit of Iran and one of the world's largest copper deposits, were investigated using hydrochemical as well as isotopic methods. Hydrochemical data were analyzed by multivariate statistical methods to give the principal processes responsible for the chemical composition of water and to specify different water types or hydrochemical facieses in the study area which are indicators of the groundwater flow paths. Statistical analyses were revealed three water groups with Ca-HCO_3-SO_4, Ca-SO_4

and Ca-Mg-SO_4 compositions in the area. The first group belongs to the peripheral regions and its evolution is mainly related to the dissolution reactions. Geochemical evolution of two other groups, which are fitted in the mining area, is associated with the oxidation of sulfide minerals and the buffering processes.
Isotopic studies were showed that all of the water resources of the study area are meteoric in origin and has undergone secondary evaporation before or during recharge and that most of the recharged water comes from high altitude parts of the basin both directly and indirectly. Tritium concentration of water samples were indicated the longer residence time of deep ground waters in respect to shallow ones. By integrating the results of hydrochemical and isotopic studies with geological and hydrogeological information, the conceptual groundwater model of the study area were developed based on which the dewatering scheme of the Sarcheshmeh copper mine pit for future years can be designed.

Keywords: Sarcheshmeh copper mine; Principal component analysis; Hierarchical cluster analysis; Geochemical evolution; AMD; Groundwater origin; Meteoric water line; Stable isotopes

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Chapter 1
Introduction

1.1 Problem statements

The development of a mine often means penetrating the local or regional water table. This causes inflows, which if the country rock is significantly permeable can become at best, a nuisance to operations and at worst a hazard (Morton and Mekerk 1993). The main disadvantages of wet working in the mines are: Increase of drilling and blasting costs, difficulties in ore handling and crushing, decrease of machinery life, slopes instability, degradation of water quality and environmental problems.

Different methods are available to manage the groundwater flow in mines; but to achieve the most effective and the least costly method it is essential that the source of the groundwater is determined and the system of groundwater is understood (Morton and Mekerk 1993). However the establishment of the source and flow paths of groundwater in fractured aquifers with complex lithology based on limited number of pumping tests and observation wells is difficult. Isotopic and hydrochemical studies can provide essential complementary information in such aquifers (Girard et al. 1997 after Geirnaert et al. 1984).

Sarcheshmeh copper mine is the largest copper deposit of Iran and one of the world's largest copper deposits (Sahraei Parizi et al. 2005; Shahabpour and Doorandish 2008). In order to reduce the problems arising due to wet working, a groundwater dewatering program is implemented in this mine in recent years, but without a better understanding and management of groundwater, excavation of the mine in lower levels in future years is impossible. The present study commenced with the aim of establishing the source and system of groundwater in the Sarcheshmeh copper mine area using hydrochemical and isotopic methods in conjunction to geological and hydrogeological studies. Due to the presence of several rock types which have been intruded during different magmatic phases in the Sarcheshmeh area and the effects of various alterations and geological structures, which sometimes have contradictory functions, the geological and hydrogeological status of this area is extremely complex. In such a complex area, where conventional hydrogeological methods failed to clarify the groundwater status, complementary studies such as hydrochemical and isotopic studies can provide useful information about the origin and system of groundwater and its residence time. Using this information the conceptual groundwater model of the Sarcheshmeh copper mine will be prepared. Based on this model the dewatering scheme of the pit for future years can be designed.

1.2 Location and access

The Sarcheshmeh porphyry copper deposit with a reserve about 1500 Mt. (SRK 2011) is a world class porphyry copper mine (Barzegar 2007). This deposit is located in southern Iran (29° 56′ to 29° 57′ N, 55° 51′ to 55° 53′ E) in a NW trending mountain belt known as Band-e-Mamzar (Fig. 1.1). The major cities close to the Sarcheshmeh district are Pariz, 15 km to the south-west and Rafsanjan, 50 km to the north. The access to the Sarcheshmeh region is by the first class road of Rafsanjan- Sirjan.

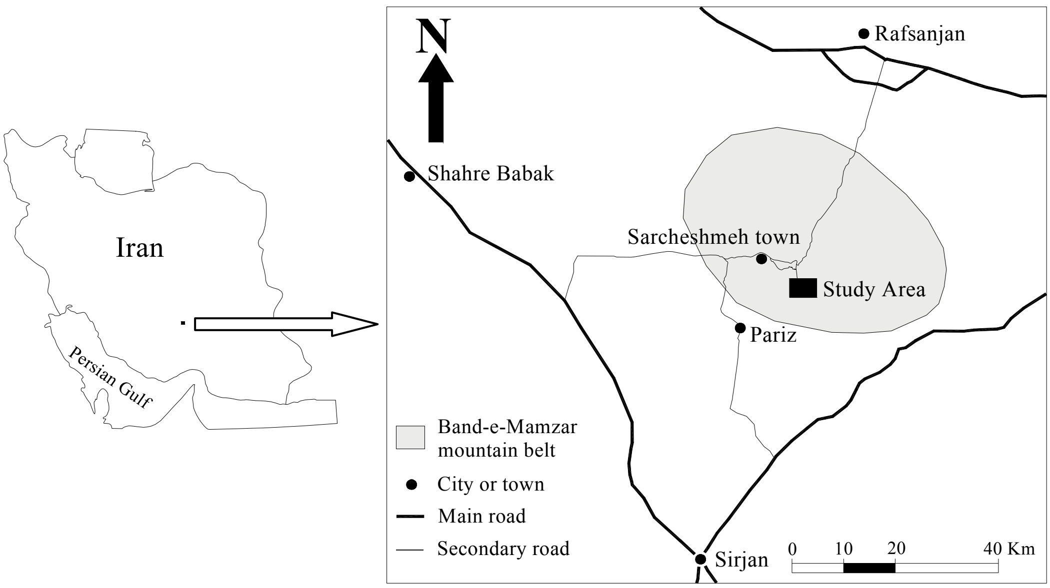

Figure 1.1. The location of the study area.

A large scale open pit mining was started up in 1974 at Sarcheshmeh by the National Iranian Copper Industries Company (NICICO). Presently the pit has an oval shape with about 3000 m long diameter and 2000 m short diameter (Fig. 1.2) which drains a basin with an area about 21 square kilometers.

Figure 1.2. The pit of the Sarcheshmeh copper mine.

1.3 Previous works

The general geology of the Sarcheshmeh copper deposit was first studied by Bazin and Hubner (1969) as a part of the geology of copper deposits of Kerman region. The first study of the Sarcheshmeh copper deposit with a descriptive nature was carried out by Waterman and Hamilton (1975).

The detailed microscopy, mineral chemistry, alteration chemistry and preliminary isotope studies of the Sarcheshmeh copper deposite were performed by Shahabpour (1982). The first hydrogeological study of the area was carried out by HATCH (2002) in order to develop the first dewatering plan of the Sarcheshmeh mine pit. Also a number of hydrogeological and hydrochemical studies were performed by author in the study area during past years (Sahraei Parizi and Karimi Nasab 2001; Sahraei Parizi et al. 2001; Sahraei Parizi et al. 2005; Sahraei Parizi and Samani 2009).

1.4 Objectives

The main objectives of this study are to:

- Evaluate the hydrochemical characteristics of surface and ground waters in the study area.
- Identify the main processes controlling the geochemical evolution of these water resources by using multivariate statistical analyses.
- Evaluate the isotopic composition of water resources of the area.
- Establish a local meteoric water line for the Sarcheshmeh area.
- Evaluate the origin and the residence times of groundwaters in the area.
- Develope the conceptual model of groundwater of the Sarcheshmeh mine pit.

1.5 Outline

The thesis has been organized into six chapters. Having introduced the objectives in chapter 1, chapter 2 describes the geology, hydrology and hydrogeology of the study area. Hydrochemical studies in addition to the multivariate statistical analyses of the water samples are presented in chapter 3. Based on these analyses water samples classified to different water groups and the main factors affecting the composition of water resources are determined and the geochemical evolution of water resources of the Sarcheshmeh area is discussed.

Chapter 4 deals with the isotopic studies of the water resources of the area. In this chapter based on the isotopic data of the precipitation samples, the local meteoric water line of the Sarcheshmeh area is developed and the origin of water resources is determined by plotting the isotopic data of water samples on this line. Also based on the determined altitude effect, the recharge areas of the shallow and deep ground waters are established.

In chapter 5 based on the geological, hydrogeological, hydrochemical and istopic studies a simple conceptual model for the ground waters of the Sarcheshmeh copper mine area is developed.

Finally chapter 6 presents summary, general conclusions and some recommendations.