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# Geotechnical investigation and design of leaching heap No. 2, Meydook copper mine, Iran

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ABSTRACT

The main objective of this paper was to investigate the behavior of waste rock material as a foundation for the construction of leaching heaps. In mountainous open pit operations, selection of an appropriate location for dumping waste rock material or building leaching heaps is a major challenge. Meydook copper mine is one of the largest copper operations in Iran. The mine has operated about 2 decades. The current waste rock dump is located 4 km from the operation site but a new proposed dump only 1 km away will be built in a valley to the North of the pit. Construction of leaching heap No. 2 has been on the mine technical department agenda. The main objective of the project is to evaluate the potential for construction of heap No. 2 on a waste dump. Considering the project condition, a 3D analysis of heap major structures including; valley rock foundation, waste dump, and low grade ore was carried out. Five sets of analyses were conducted and the displacement and stress fields were computed. In all analyses conducted, the subsidence profile was determined for the valley base rock and heap foundation (waste dump). The analyses showed that the maximum settlement at the heap base would be only 4–5 cm so the waste dump provides a safe and reliable base for the heap construction. A sensitivity analysis of heap mechanical parameters was also conducted. The results showed that if the friction angle of heap material was reduced below 25°, the heap walls became unstable and the heap geometry would need to be redesigned.



## 1. Introduction

Meydook copper mine is the second largest copper open pit operation in Iran. Meydook mine is located in mountainous region 42 km NE of Shahrebabak city in Kerman province, Iran. Considering the mine area topography and environmental constraints, selection of proper location for dumping waste material and construction of low grade heap has been a challenge for the mine management. Construction of the leaching heap No. 2 has been part of the mine development program. In order to construct the heap, an approximate area of 20,000 $m^2$ of flat ground was required. The heap would be constructed with low grade copper ore in 5 m lifts with acid sprays to leach the contained copper mineral. Fig. 1 illustrates the leaching process.

Considering the high topography of the mine area, the limitations in appropriate sites and the high cost associated with excavation and preparation of an appropriate site, it was proposed to dump waste material in a valley 1 km from the pit and then construct the leaching heap on this dump. Proximity to the mine and processing plant were the key parameters in selecting the leaching site. The mines current waste dump is located 4 km from the pit. The valley dump would reduce the transport distance from 4 to 1 km which would dramatically reduce the waste transport costs of the mine and would accommodate 40 Mt of waste material. The valley is located to the North area of the pit and west side of the processing plant. Valley area, once half filled, would easily accommodate the leaching heap. The close proximity to the pit and processing plant are attractive aspects of the proposed site. However, mine management had some geotechnical concerns with the construction of leaching heap on waste material. The in-situ mechanical behavior of waste material was unknown and the mine management was worried about the stability of waste material acting as a foundation for the heap. Hence, this research work was initiated to investigate the geotechnical aspects of constructing a leaching heap on waste material. The results obtained from this study are presented in the following sections.

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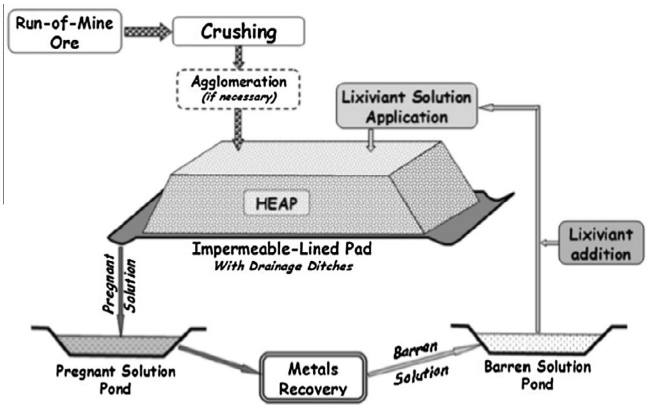


**Fig. 1.** Schematic illustrating the leaching process.

## 2. Geotechnical investigations and heap No. 2 design parameters

From a geological perspective, the Meydook copper mine is located in central Iran zone. The formation of this zone is associated with extensive volcanic and tectonic activities. Diorite porphyry is the host rock for copper mineralization at Meydook. Fig. 2 shows an aerial photo of the Meydook copper mine illustrating the location of proposed valley for the construction of heap No. 2. The selected location is a wide and long valley with shallow slopes. The valley foundation rock is andesite with slight alteration and has a fairly good strength. Fig. 3 illustrates a view of the valley looking North.

From a geotechnical design point of view, the main design parameters are rock mass deformation modulus, in-situ compressive and tensile strengths, cohesion, and friction angle. The main geotechnical domains involved in the construction of heap No. 2 are; the valley foundation rock, the waste material (rock to be dumped in the valley), and the low grade crushed copper ore

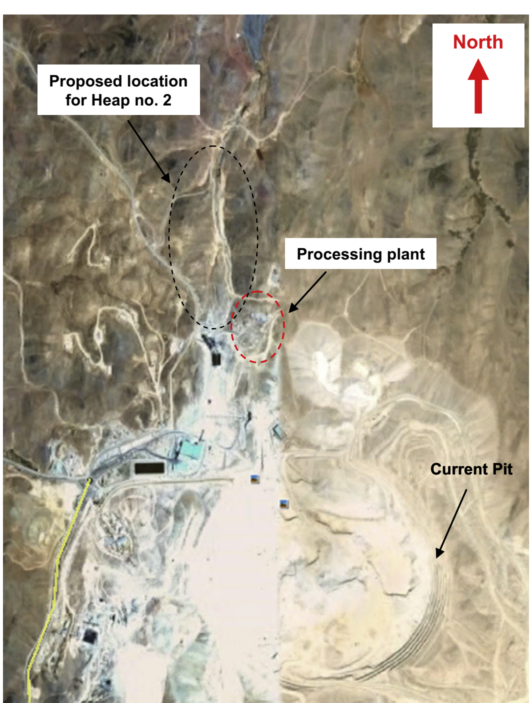


**Fig. 2.** An aerial view of Meydook copper mine.

**Fig. 3.** Heap No. 2 site location (looking north).

(heap). The geotechnical concerns for the site were the major faults that exist in the valley foundation and could impose instability into the heap structure. Moreover, the heap interface, which is a thin layer of gravel and clay, plays an important role in the overall heap stability. Accordingly, five geotechnical units were considered in the geotechnical design of the heap. Based on available geological and geotechnical studies conducted at Meydook copper mine, a geotechnical characterization of each unit was carried out and heap design parameters were determined. With regard to lack of sufficient data for some units, engineering judgment and field observation were used as a base for the characterization of these units. Consequently, five geotechnical units were defined; valley rock which is Andesite Tuff (AN-TF), major valley faults (FAULT), low grade copper ore (HEAP), mine waste rock material (DUMP), and heap-dump interface (LINER). The methodology adapted to determine design parameters are outlined as follows.

*The AN-TF unit:* For this unit, the laboratory studies and field mappings conducted by mine geotechnical department were combined through Hoek–Brown criteria (Hoek and Brown, 1997) and the rock mass data was determined.

*The FAULT unit:* Based on site investigations and field mappings four major faults were identified in the heap construction site valley. Fig. 4 shows a plan view of the valley topography indicating the fault location and geometry. Faults F1, F2, and F3 do not have a filling material, but fault No. 4 has a 4 m shear zone thickness and runs N–S.

With regard to the nature of crushed material in fault zones, a GSI value of 25 was assigned to this unit and the Hoek–Brown criterion was used to determine the design parameters.

*The HEAP unit:* This unit is basically crushed low grade copper ore which is stacked in layers of 5 m in height to form the heap structure. The mechanical and strength parameters for this unit were taken from the data determined during the Meydook heap No. 1 construction.

*The DUMP unit:* Determination of the design parameters for this unit was very challenging. This unit was supposed to be constructed by dumping millions of tons of waste rock in the valley over a 1–2 years period. The waste rock would be transported from mine to the valley by 250 ton dump trucks. It was very difficult to conduct any test either in the laboratory or in the field scale on the waste rock material. Additionally, during the dumping process, in a confined valley, truck movements on the dumped material would compact the waste rock and alter its nature from a loose material to a consolidated mass. Hence, any testing program on the dumped material would have been time consuming, costly, and probably not useful. The mine waste material was previously used, in a similar scenario, to build a ramp on mine South wall. The ramp has been in service for more than 5 years. The nature of Meydook waste rock is such that it has a very good size distribution and interlocking characteristics. Once compacted, it acts as a fairly