

## Application of Van Ruth Wire Line Core Orientator at The Sarcheshmeh Open Pit Mine

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**ABSTRACT:** Slope stability analysis and ground water effects at the Sarcheshmeh mine is one of the issues that would not be accurately addressed without a comprehensive understanding of the structural characteristics of dykes, faults and joints sets. For better understanding of these structures, a few geotechnical boreholes were drilled at the west, south and east sides of the mine. In conventional core drilling method a complete analysis cannot be performed due to the lack of core orientation. Orientation of the core can be easily done with a core orientator. Using triple tube core barrels and Van Ruth downhole device, core can be recovered and oriented. This paper discusses the measurement and data collection procedures and also the difficulties that have been experienced with the Van Ruth device.

### 1 INTRODUCTION

The Sarcheshmeh porphyry copper-molybdenum deposit, which ranks among the largest in the world, is located in southern Iran. A large scale open pit mine was started-up, by the National Iranian Copper Industries Co. (N.I.C.I.Co.) in 1974. It is currently the largest open pit mine in Iran. The Sarcheshmeh pit is oval shaped, about 3000m long by 1800m wide. The ore body contains 1200 Mt. of ore averaging 0.7% copper and approximately 0.03% molybdenum. The mine produces 100,000 tons of copper and 2200 tons of molybdenum concentrate per year.

The importance of obtaining correct and confident geotechnical data for existing mining projects can not be underestimated. This information is necessary to adequately characterize the geotechnical properties of the ore body and define parameters for stability and hydrogeological analyses that are commonly required as part of the open pit mine design.

The characterization of the structure of rock masses is an important consideration at the Sarcheshmeh mine. Often it is the discontinuities and joints and not the intact rock that governs the mechanical and hydrological behavior of the rock mass.

Rock characterization using oriented borehole core data, is often more useful because it is cost effective, and can target the exact location of important structure.

This paper presents simplified field procedures and description for the collection of pertinent geotechnical data from drillcore.

### 2 DRILLCORE ORIENTATION METHODS

Drillcore orientation methods are commonly employed where there exists an absence of, limited surface rock outcrops to allow for the definition of the orientation of the main rock mass structure. The most common drillcore orientation methods can only be used with inclined drillhole and comprise the: clay imprint method, which has been, reported by Call, Savely & Pakalnis. (1982), Craelius method reported by Rostrom (1961). There are a number of other oriented techniques, including borehole photography, core-scanning technology Paulsen, Jarrard & Wilson. (2002) and georadar penetration radar Relgi, Huggenberger & Rauber. (2002).

Van Ruth core orientator, which is similar to the Craelius core orientation device is, performed at Sarcheshmeh mine.

In conventional core drilling method a complete analysis cannot be performed due to the lack of core orientation. Orientation of the core can be easily done with a core orientator. Using triple tube core barrels and Van Ruth downhole device, core can be recovered and oriented. Van Ruth core orientator consists a metal holder, with the same diameter as the core, which contains the movable pins Figure 1.

Figure 1. Van Ruth core orientator device.

### 3 DISCONTINUITY DATA ANALYSIS

Van Ruth method comprises an instrument with a conical probe and finger pins along end that is connected to the core barrel and pushed downhole against the core stub left by the previous drill run.

Van Ruth core orientator is based on gravity and only works consistently and effectively for inclined holes the finger pins form to the profile of the core stub. The instrument is removed and fitted to the core from the subsequent drill run to allow for the scribing of the reference line representing the bottom of the core Figure 2.

Van Ruth, establish the position of the vertical plane on the rock at the bottom of the hole, before each run is drilled and pulled from the ground. How often this procedure needs to be done depends on the degree of fracturing of the core. If the core is extracted in coherent sticks whose broken ends can be readily fitted together, then a single core orientation mark may serve to orient several runs of cores. However, if the core is very broken with fracture zones and core loss, only a small section of the core may be oriented by a single mark. This may not matter much if the structures are simple and fairly constant throughout the hole but where structure is complex, such as the case of Sarcheshmeh mine, a large percentage of the core will need to be oriented. Whatever spacing between orientation survey is finally chosen, any unsuccessful attempt to orient a run of core should be followed up with another attempt on the succeeding run.

With the Van Ruth core orientator method the orientation of the joints can then be measured in terms of the relative "alpha" and "beta" angles. "Alpha" is the angle of the maximum dip of the discontinuity with respect to the core axis and "beta" is the radial angle measured clockwise relative to reference line looking down core axis in direction of drilling Figure 3.

The bottom of hole orientation mark established on the end of a core run is used to draw a reference line along the entire length of the run, and along adjacent runs that can be matched to it. The orientation mark represents the bottom of the hole, this point should be transferred to the top surface of the core. Transforming the orientation mark to the top surface of the core can generally be done by eye with sufficient accuracy.

The line drawn along the core marks the intersection on the surface of the core of the original vertical plane passing through the long core axis.

Since the orientation of this plane at any given depth is known (from down-hole survey), the marked line can now be used as a reference plane to measure all the structure in the core.

Because of minor errors in orienting, reassembly and marking the core, it is seldom possible to exactly match the orientation lines from two adjacent oriented core runs. However, a large mismatch, greater than 10°, indicates that the processes described above should be carefully repeated.

### 4 RELIABILITY OF THE ORIENTATION TECHNIQUE

The reliability of this orientation method can be tested by conducting rotation cluster tests on natural fractures in the core Paulsen, Jarrard & Wilson (2002). Fractures should show an improved clustering after rotation because they typically have systematic orientations. Overall, we estimate an orientation uncertainty of  $\pm 10^\circ$  for entire stitched core intervals and  $\pm 15^\circ$  for individual features such as a single fracture. Some of the error results from each step of orientation process Paulsen, Jarrard & Wilson (2002).

The quality of discrimination between sets varies with borehole orientation, the number of sets and the orientation and concentration parameters of each set. Terzaghi (1965), Chiles and de Marsily (1993) mentioned this problem so finding favorable borehole orientation for classification is important. Long boreholes may traverse through more than one geological or structural domain. Consequently during the analysis, it often proves useful to split the data set into different geotechnical mapping units.

In the case of the analysis of oriented core drilling, there is a directional bias, first documented by Terzaghi (1965).

Discontinuities that are near perpendicular to the borehole are much more likely to be intersected during the drilling process than discontinuities that are near parallel to the borehole.

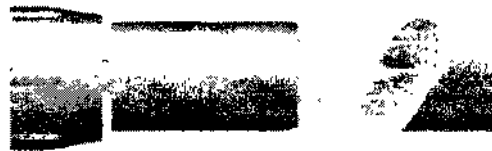


Figure 2. Finger pins form to the profile of the core stub.

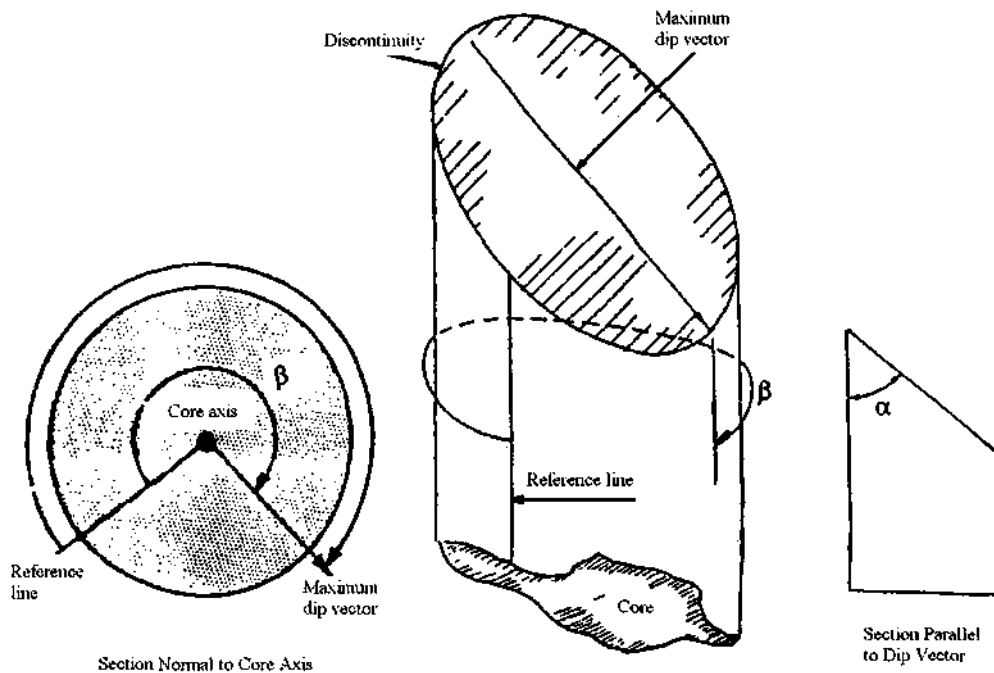


Figure 3 Definition of the orientation pair, alpha and beta, for borehole core logging data, (after Diederichs & Hoek).

Therefore, a borehole that is optimally oriented with respect to the structure orientations will yield the most accurate data. In addition, an oriented drilling program incurs significant drilling costs, and in order to maximize efficiency, it is highly desirable to intersect as many discontinuities as possible in a given borehole.

Thus, the prediction of optimum drilling angles is of great importance.

## 5 USING A STERONET

Extra handling procedures are necessary for oriented drill core. The steronet can be used to quickly and simply calculate orientations as the core is being logged. For the traverses that through a uniform geological or structural domain the results of separate equal area projections of fractures for each run should be approximately similar.

Figure 4, indicated that in some instances there are large differences between the means that occur in two adjacent oriented core runs. This variation is due to the errors in orienting reassembly and marking the core. However, a large mismatch in a uniform geological or structural domain should be

carefully corrected base on the adjacent oriented core runs.

Oriented coring is used to determine whether the geologic structural domains, which were mapped on the surface, extend back behind the pit walls.

The discontinuities collected by scan-line method along the slope face of western side of the Sarcheshmeh mine and joints encountered along oriented boreholes behind the slope face were compared Figure 5. The analysis of discontinuities indicates that the oriented data is more scattered than is the surface mapping data because the oriented core represents only 7 to 15 cm' of the fracture plane. Consequently, it does not represent an average orientation. Also the oriented core has a definite blind zone, which must be considered when analyzing the data.

## 6 RESULTS AND CONCLUSION

The overall strength and permeability of rock mass and the stability of engineering structures are influenced by joint orientation.

Rock characterization using oriented borehole core data, is often more useful because it is cost

effective, and can target the exact location of important structure the performance and limitation

of this approach are:

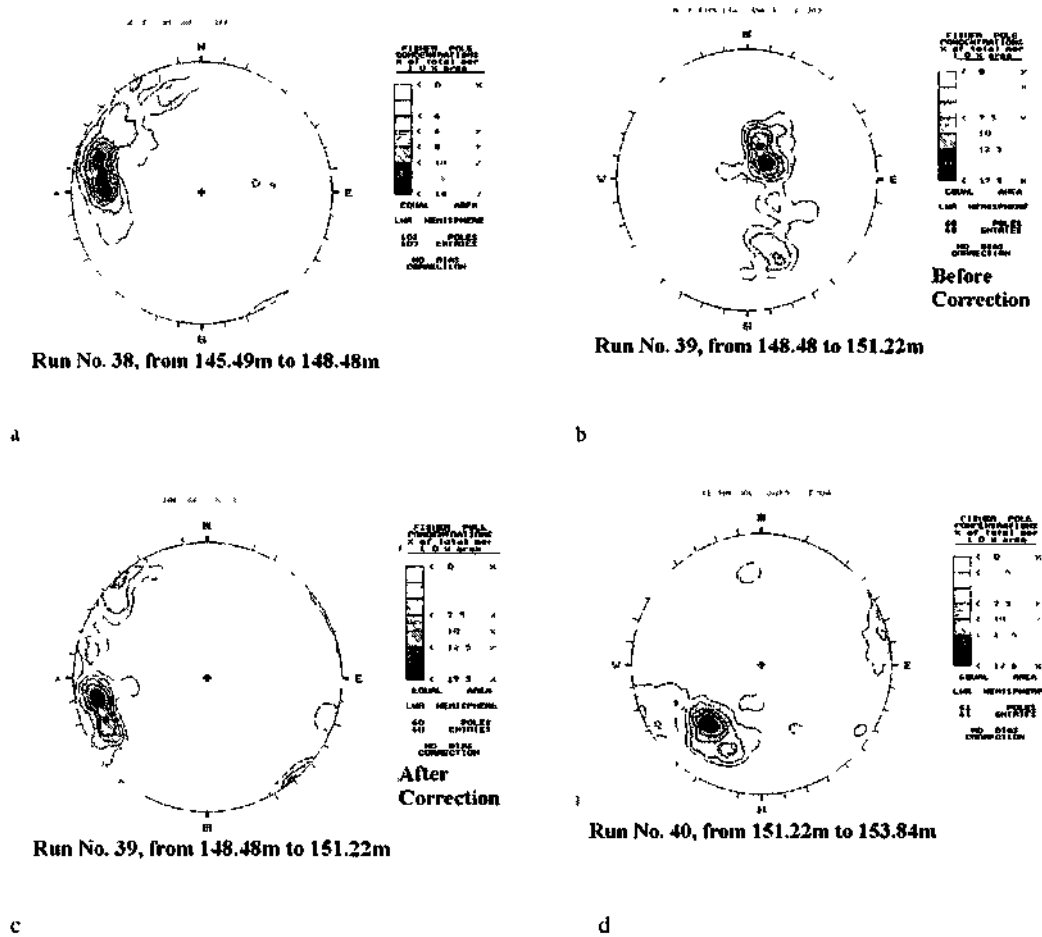


Figure 4 Contour plots of the geotechnical boiehole No GTC04 at the west side of the Saichehineh mine, a) Run No 38, b) Run No 39 before correction, c) Run No 39 after correction, d) Run No 40

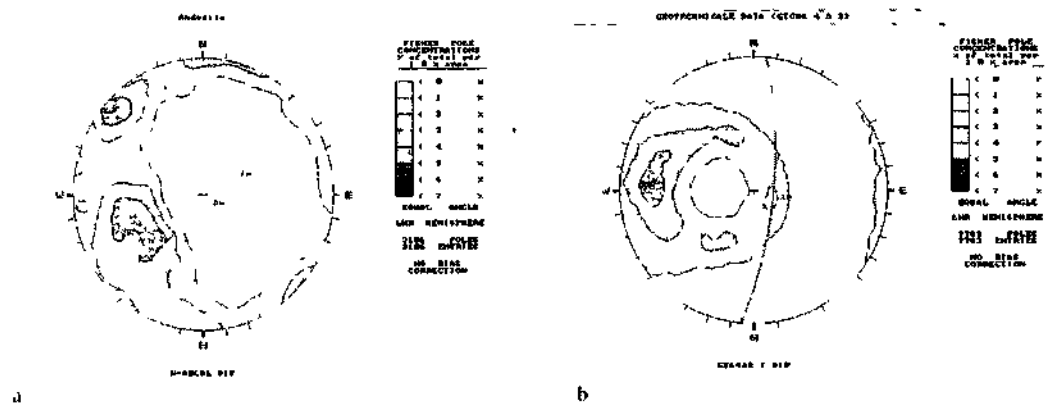


Figure 5. a) contour plots of discontinuities collected by sea i-line, b). contour plots of discontinuities encountered along oriented boreholes behind the slope face

- Discontinuities that are near perpendicular to the borehole are much more likely to be intersectedduring the drilling process than discontinuities that are near parallel to the borehole.
- Joints encountered along oriented boreholes can be oriented in 3D. Oriented joints may then be analyzed on a steronet and joint sets identified. The intensity and statistical dispersion of each joint set along boreholes can then be computed and serve as a basis for joint simulation over the entire rock mass. Ideally, every intersecting joint should be fully oriented. Unfortunately this is seldom practicable from a technical and economical point of view.
- Van Ruth such as other mechanical core orienting tools will not work where the end of the core is smooth, so flushing loose chips and sludge from core face holes by raising rods 25 to 30 mm from hole bottom is necessary. However, for long borehole if the core is very broken with fracture zones and core loss this procedure will unsuccessful attempt to orient a run.
- Mechanical core orienting tools are based on gravity and only work consistently and effectively for inclined holes so the system will not work where the end of the core is normal or close normal to the core axis.
- Where an orienting tool is run, there may be twists in the core or poor quality control by operator that make the orientation of the core dubious.
- Oriented core provides fracture orientation and spacing data, but length data cannot be determined with this technique.

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#### REFERENCES

- Call. R. D., Savely. J.P & Pakalnis. R. 1982. A Simple Core Orientation Technique. *17<sup>th</sup> Stability Surface Mining Conference*, Vancouver. B.C.
- Chiles. J.P.& de Marsily. G. 1993. Stochastic models of fracture systems and their use in flow and transport modeling. In: Bear. J., de Marsily. G. & Tsang. C.F., (eds.). *Flow and contaminant transport in fractured rock*. Academic Press. San Diego. 169-305.
- Diedenchs M. & Hoek E.. 1996. *User's guide of Dips, version 4.0*. Rock Engineering Group. University of Toronto. Canada.
- Paulsen Timothy S. Jarrard Richard D. & Wilson Terry J.. 2002. A simple method for orienting drill core by correlating features in whole-core scans and oriented borehole-wall imagery. *Journal of Structural Geology* 24: 1233-1238.
- Regli Christian. Huggenberger Peter & Rauber Martin, 2002. Interpretation of drill core and georadar data of coarse gravel deposits. *Journal of Hydrology*. 255: 234-252
- Rostrom. E. 1961. Craehus automatic core onentator. *Canadian Mining Journal*. p. 60-61.
- Terzaghi. R. D.. 1965. Sources of error in joint surveys. *Geotechnique* 15 (3): 287-304.

