# Oriented Core - What the ... ?

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## Background

Considerable valuable structural geological information can be gained by geologists from oriented drill-core. This data can be used to enhance geological models and provide parameters for resource estimation. All too often, however, structural data gathered from oriented drill-core is inaccurate, not taken in correct geological context, or not used at all.

Many of the problems are a function of inexperience in dealing with core orientation methods at the front-end, lack of care and knowledge during the mark-up process, and deficient geological manipulation and interrogation of data at the collection and interpretation stages. Many of these problems are commonly amplified by ineffective dialogue between the geologists and drillers, followed by a less than professional approach to management of the whole process.

A detailed description of all the available core orientation methods currently in use is beyond the scope of this talk. Rather, a number of situations and examples are presented where oriented core has been integral to major drilling campaigns. This abstract accompanies the talk and attempts to highlight some of the problems encountered, with solutions where pertinent.

## Problems Incurred While Drilling and Initial Core Orientation

### Methods of Core Orientation

Down-hole survey data provides the plunge and plunge-direction (azimuth) of the axis of the core. However, additional mechanical devices are needed to provide information to fully orientate the cylinder of core. These methods determine the orientation of the face of core at the drilling break between core runs and the most common methods include the down-hole spear, Ezy-Mark® and Ballmark® and Reflex® systems.

Industry standard appears to be phasing out the use of the spear because it is generally considered less accurate than these newer methods. However, the spear method is still very common and many of the problems encountered are not a product of the technique but rather result from poor techniques at some, or all of the stages from orientation to mark-up.

### Potential Problems With the Methods

The spear orientation method is the simplest for orienting core and, when done properly, can yield accurate and consistent data. It consists of a lowering a heavy steel spear with a sharp point or a wax-pencil tip on a wire-line inside the drill rods after the inner tube is removed. The spear hits the bottom of the hole producing a mark on the next piece of rock to be cored. The heavy spear slides along the bottom of the rods and the mark or chip on the core will identify the bottom edge of the core. Good quality spear orientation marks will occur as discrete marks near the edge of the core.

Although the spear orientation device is very simple, several problems can arise, including:

- The drill-bit may not be on the bottom of the hole
- The tip must be firmly screwed into the spear to prevent it and the spear from bending. A bent spear tip will produce inaccurate results.
- The tip of the spear should be a sharp taper. A thick nut or some other holder for the tungsten tip or crayon will result in the mark being too far in from the edge of the core.
- The spear should be lowered so that it produces a single punch mark. If it is lowered too slowly it will fail to produce a mark and if it is lowered too fast the spear may bounce producing multiple marks or streaked lines. The correct speed will be dependent on the angle of the hole and the hardness of the rock and can only be determined by trial and error.
- The angle of the hole may be too great or too low. Best results are obtained in drill holes with plunges between 35° and 75°. The depth of the hole should not significantly affect the quality of the marks.

The Ballmark system relies on punching an aluminium washer with a ball that revolves under the influence of gravity. This mark represents the bottom of hole and the orientation relative to reference mark gives the location of

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the bottom of hole orientation line. Errors can occur if the aluminium washer is punched too soon i.e. before the ball has stopped revolving in the hole. In some cases two indents can be produced on the same washer. This can be due to lowering the rods too quickly, causing compression of the spring when the rods hit the bottom of the hole.

The presence of factors such as a water table must be considered in holes when using the Ezy-Mark as these can cause the device to fire prematurely before they contact the broken face on which the orientation mark needs to be made.

The Reflex tool was known as the ACE tool historically and is by far the most sophisticated in terms of its inner working, comprising digital read-outs, internal silicon accelerometers, and electronics. In the past the the Ace tool was returned to surface on completion of the drilling run and the user entered the time at which the core was broken based on a readout on a stopwatch. The tool recalled the associated accelerometer information for the same time period from its memory and then guided the user to position the tool and core barrel so that the same low side position was reproduced on the surface.

The marking of the orientation was originally prone to error because it relied on accurate measurement of the amount of time from when the reading was taken relative to when the rods were lowered. This potential area for error has been rectified in the latest instruments and stopwatches are no longer required as the instrument automatically records time and date. LED lights and an audible signal now compliment the LCD screen to direct the operator towards the correct orientation alignment.

Using the Ace V jig provided, the core is marked at the lifter case end of the sample. The mark should be made on the end of the core. In some cases I have seen the drillers put the orientation mark on the outside of the core, which is then removed when the core is slid out of the barrel. The drillers then attempted to determine where the mark was.

A general problem that is inherent in many drilling campaigns is the inexperience of the geologist or the driller or both. This can result in generally poor results and can affect factors as simple as when the orientation mark is made. Generally, the capture of an orientation by the driller is factored into the contract, typically within the metre rate. I have seen examples where an orientation charge has been agreed upon and the drillers have then proceeded to take orientations every 40m or more. This is unacceptable and was the fault of the geologist not checking the frequency of orientation marks and the drilling foreman not adhering to the agreement.

## Potential Solutions to Poor Core Orientation at the Rig

The frequency of orientation marks will usually be every 6m if the drill rig is completing 6m core runs. If the drill-rig is completing 3m core runs and very accurate structural data is required, orientation marks could be taken every 3m. The onus is on the geologist to check the frequency of the marks and to check the quality of every one of them. This is not an onerous task and there is no excuse for not doing it.

It may seem obvious but the representative of the company supplying the orientation method should be at the drill rig for every shift when the method is implemented. For example, if the ACE method is introduced then an ACE representative should cover every shift with all drillers and the drilling foreman until everyone is familiar with the method. At this stage the onus is on the geologist managing the project to become familiar with the method as well. A simple problem that commonly occurs is that the driller transfers the orientation mark incorrectly from the face of the core to the outside of the core or vice-versa. Both marks need to be checked in the coreyard during the next marking up phase.

Geologists and drillers should both be comfortable that the method being used is working well. In some cases it will be necessary to do a comparison of methods to see if similar methods are achieved e.g. using both the Ezy-Mark and a spear.

The geologist should always check the correct shape and tolerances of spears that have been manufactured 'on-the-spot'.

The driller responsible for the orientation mark on the core should put his initials on the block at the same core break. Although the driller should be able to be identified from the drill plods, the initial on the block make the task easier and they make the driller aware of his responsibility in the core orientation process.

As a final comment, sometimes the sophisticated methods such as ACE just don't seem to work. I have seen occasions where both the geologists and the ACE representatives could not resolve why the instrument was giving variable orientations across shifts and using different drillers. This has been in cases in the Arctic, where the problem could perhaps be attributed to the effects of cold on the instrument, through to cases where good drilling conditions were present and the problem was perhaps attributable to the instrument. The instrument is rated to -30°C and conditions in the Arctic were commonly colder than this.

In such cases, where more than one instrument in each of the non-spear methods is being used on the same hole, the blocks need to be marked with the instrument number. Also, a number of continuous orientations need to be taken with each instrument in order to check the repeatability of the measurements.

## Problems at the Marking Up Stage at the Rig and in the Coreyard

Since each orientation mark has an unknown accuracy, it can only be accepted if it correlates with one and preferably two or more of the other orientation marks. To make an orientation line the core should be reconstructed between the orientation marks in a V-rail (angle-iron) that is at least several runs long. For example, if using a 6 metre barrel then at least 20 metres of angle iron should be available to lay the core out on.

By drawing a line along the bottom of the core, which joins the individual BOH marks, we are able to provide an "orientation line" from which the true orientation of the planar and linear structures in the drill core can be determined. The accuracy of the orientation line is critical to the quality of the orientation measurements. If the orientation line is not correct all measurement made relative to the line are inaccurate and the data collected will be incorrect and misleading.

Prior to marking the orientation line the core must be carefully reassembled. This may require gluing together of core fragments in critical areas. Every break must be carefully inspected to assess its validity in terms of coherent joins. Failure to do so will result in misaligned core and hence an inaccurate line. Even many apparently tight joins are the result of drill-induced grinding and the orientation line can not be carried across these. The line may be extended up to several metres past the last orientation mark provided that the core can be confidently reconstructed. The points at which an orientation line is stopped and the reason for the termination should be recorded on the orientation record form. In extreme situations where orientations are critical, a single reference line may be extended for many tens of metres in competent well-oriented core although this is not advisable.

The correct way to position core in V-rail is with orientation mark parallel to edge with a pen held horizontal to the edge of the V-rail. The pen should be kept horizontal when drawing the reference line. It cannot be stressed how important it is that the pen be kept horizontal. The tendency is to roll the wrist as the mark is put on the core but this can cause a progressive deflection of the orientation line from what it should be. The ultimate result will be an orientation line that spirals around the core!

### Methods of Measurement and Comments on Interpretation

Collection of data is principally done directly via measurement in core orienting frames, or indirectly by taking alpha and beta and gamma readings and then calculating true orientations via a spreadsheet or some form of canned software.

Numerous forms of core orientation frame are available, from commercially produced ones to those that have been manufactured on-site. All of these will work well although care has to be taken that they are made entirely of non-magnetic material! Failure to do so can produce some interesting (erroneous!) results.

In the case of alpha and beta measurements the introduction of the Kenometer has been extremely useful.

It is recommended that initially a core frame/rocket launcher is used for the measurement of structures in oriented core at the start of each individual project. This permits direct visualization of the structures in their original orientations. If a considerable amount of data is required quickly, the alpha-beta-gamma method can be used. If using the alpha-beta-gamma method, it is a good idea to also have a core frame so that structures can be visualized, non-penetrative linear features can be measured and checks on the alpha-beta-gamma measurements can be made.

## Concluding Comments

A geologist must take ownership of core orientation and data collection. Don't simply trust the drillers and the geotechs further down the line to get it right!

Never, ever assume the core is correctly oriented. Perform some checks e.g. measure a feature that has a consistent orientation regionally and check that it conforms.

A "rocket launcher" should be used initially for oriented core at the start of each project and regularly throughout the logging process. This permits direct visualization of the structures. A rocket launcher should always be on hand for check measurements, and for measuring non-penetrative linear features (e.g. fold hinges).

If a large amount of data is required, the alpha-beta-gamma method should be used. Use of equipment such as the Kenometer can facilitate this.

A number of core orientation methods are available and the industry is still achieving a broadly accepted standard. Those methods with more than one independent check on orientation, and those with the least number of moving/mechanical parts, will become most widely used.

Modest amounts of good quality, from well-oriented drill-core, data are much better than large amounts of poor quality data.

A geological history that combines paragenetic and deformation histories is an essential framework to constrain geometric relationships gathered from oriented core.