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ORIENTED SAMPLES – A POWERFUL, YET UNDER-UTILISED, TOOL FOR UNDERSTANDING MINERALISATION

A PRACTICAL GUIDE TO THE COLLECTION OF ORIENTED SAMPLES AND PREPARATION OF ORIENTED THIN SECTIONS

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Introduction rant

Oriented samples can be a valuable tool for understanding volumes of hydrothermal mineralisation, especially when the mineralisation has been influenced by deformation. As mentioned in previous posts, structural geology is at the top of the tree in terms of its role in the formation and modification of mineralisation. Very few volumes of economic mineralisation lack structural geology in their evolution, be it in the form of permeability networks, displacive structures, stockwork formation adjacent to major fluid pathways, ductile to brittle overprints etc.

Many structural geology textbooks and papers have been published on the interaction of structural geology and mineralisation. In order to make the publications sexily pertinent, a lot of these will use the term 'applied' somewhere in the title, or boast 'new paradigms' to draw in the reader or conference attendee. In a lot of cases, the authors and/or events succeed in delivering some pragmatically applicable information or techniques. But, just as often, they do not. How many papers with the words 'applied', or terms such as 'new method', have you seen where the contents are anything but applicable. I've seen some papers that are full of mathematics that would make Erwin Schrödinger cringe. Don't get me wrong – the authors are smart dudes (being as 'woke' as I am, I probably should include dudesses – or should I simply create a new term and collectively call them dude-ites? Or duderines?), but they are missing much of their audience apart from the academic propellor-heads.

So, to the reason for this post. Historically, very few people have described how to take an oriented sample. The exceptions that I could easily find are in the reference list at the end of this article, and include my own post that I made 10 years ago.

Given that my own work came up in a Dr Google search, I have blatantly plagiarized some of my earlier discourse to provide information on how to collect an oriented sample, and to emphasise the importance of this technique in deciphering orebody evolution and structural controls. Oriented samples are essentially portable outcrops that allow structural measurements to be taken in the coreshed/office etc i.e. away from the point of collection. Ease of examination is enhanced by being able to cut the samples in any orientation desired, thus allowing a view of structural and overprinting relationships on fresh faces.

Oriented samples are portable outcrops

Mine and exploration grids are typically established such that they have orthogonal relationships with the trend of mineralisation. Although traditional sectional interpretation can be a flawed method for modelling geology, it is still super common because sections overwhelmingly contain the drill fences. Given this, here are a few of the powerful things about oriented samples:

- They can be cut parallel to drill section orientations, and/or parallel to section orientations that give the best view of geological relationships in 3D models.
- Apparent dips and kinematic relationships can be transferred directly to the sections.
- Horizontal slices can be made that allow strike information and kinematic relationships to be transferred directly to plans. By establishing the best viewing orientation to examine structural relationships, the oriented samples can be cut normal to this.
- Sometimes the structures are simply too hard to measure in an outcrop, either because they are unclear (lichen, blast damage etc) or not sufficiently exposed (e.g. Figure 1).
- Oriented samples in turn allow the preparation of oriented thin sections that can reveal orientational information not visible to the naked eye in hand specimens.

Figure 1 – Sometimes it is just too hard to measure the structures in an outcrop and a sample has to be taken.

Unfortunately, geologists in industry rarely know how to take an oriented sample. All it takes is the ability to measure a dip and dip direction. Sadly, some people don't even know how to do this. For these reasons, this article concentrates on the process of taking an oriented sample. It then expands on the technique by describing how to take an oriented thin section.

Procedure for taking an oriented sample

Figure 2 shows the procedure for taking an oriented sample. The rock with structures to be examined is selected and a dip and strike symbol is placed on a flat surface. The top of the dip and strike symbol needs to be horizontal, and the edge of a compass with a leveling bubble can be used to determine this. Note that the surface just has to be flat – it does not have to correspond to bedding or a cleavage. The orientation of the surface is recorded – in Figure 2 it dips at 70° toward 330° (dip and dip direction).

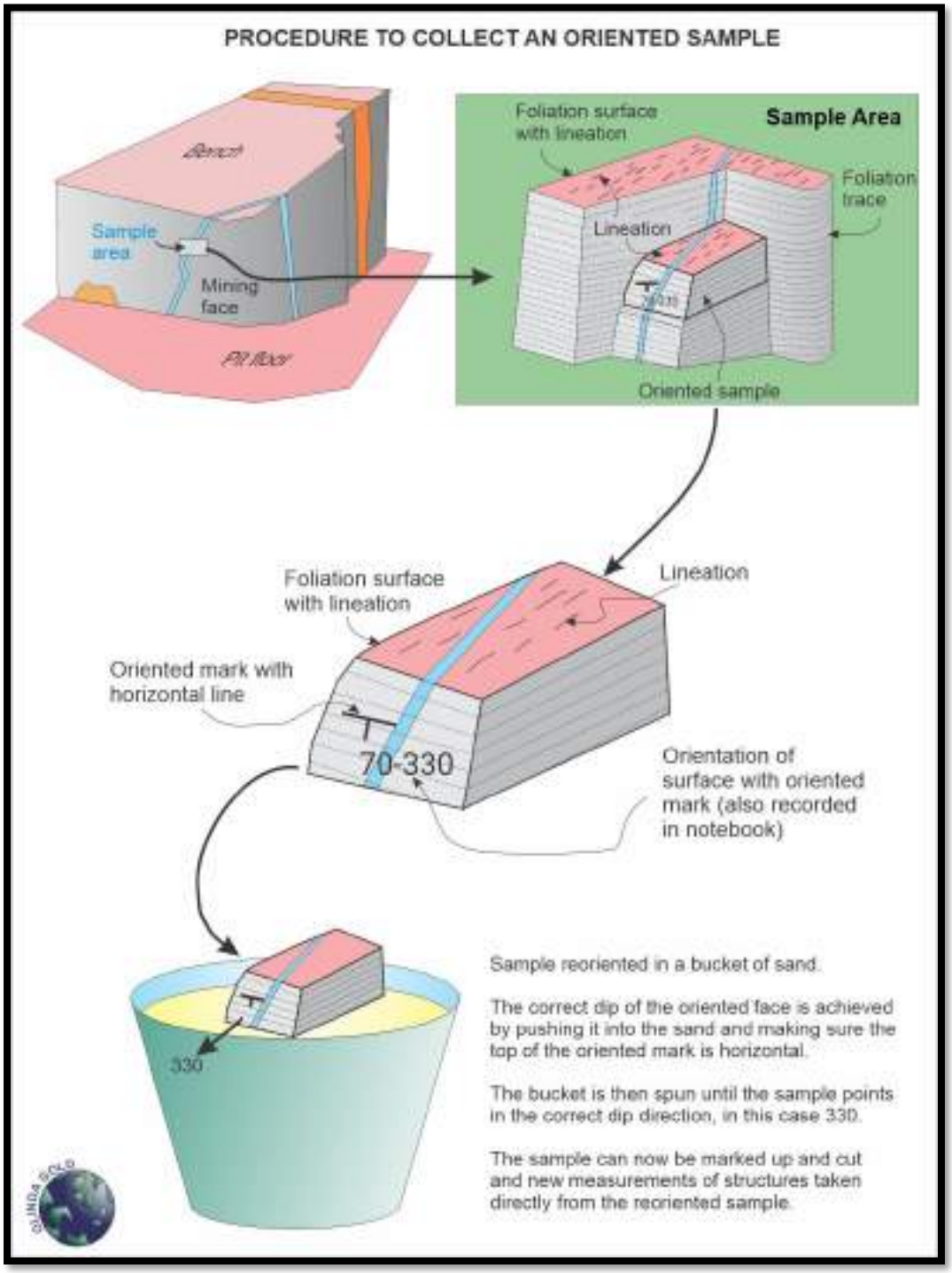

Figure 2 - Method for taking an oriented sample.

Sometimes the surface on which the mark is placed will be overturned (Figure 3). Make sure that a note is made of this, and the appropriate symbol placed on the overturned surface (Figure 3). The reason for this is apparent if we consider the sample in Figure 3. It could have a parallel face dipping at 70° toward 300° (dip and dip direction) at the back of the sample. However, the exposure on this rear-facing parallel surface faces downward i.e. it is overturned and needs to be indicated as such so that the sample can be correctly reoriented (Figure 3).

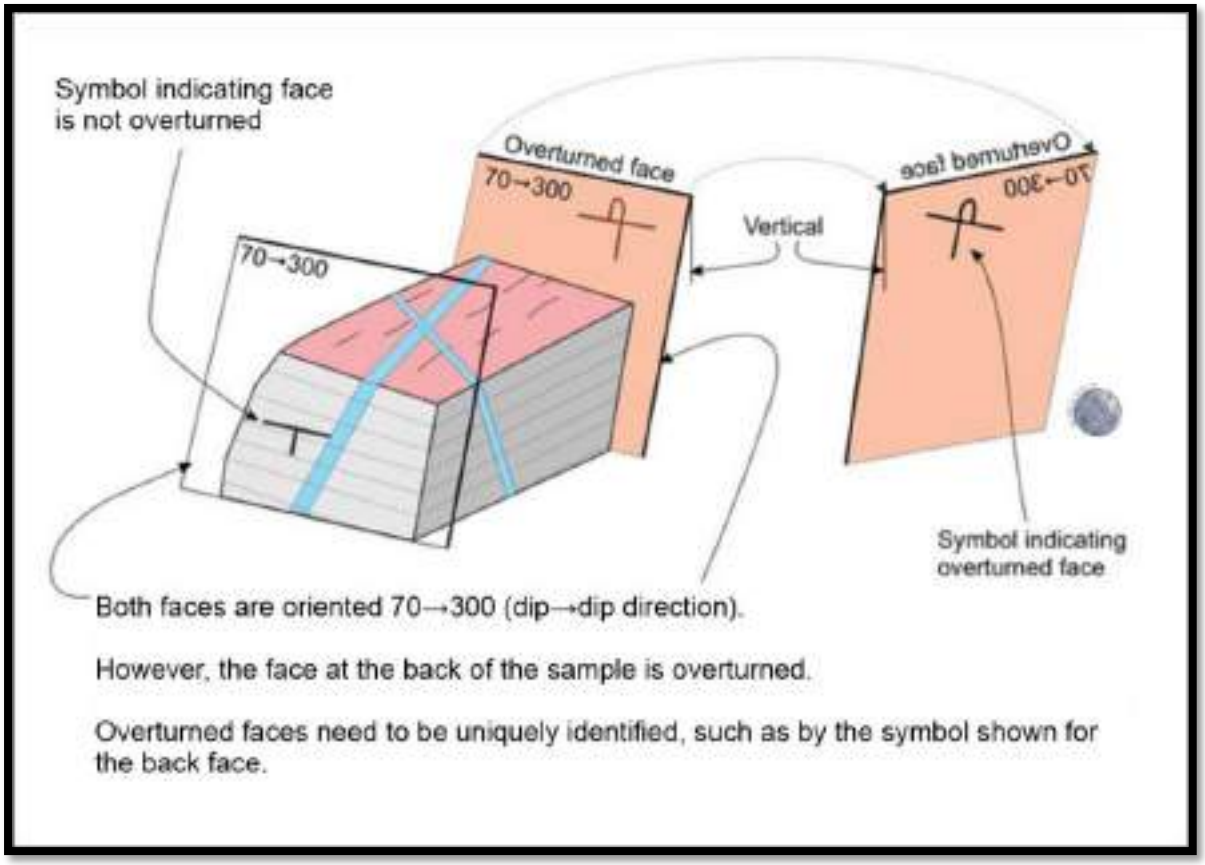

Figure 3 - Cartoon showing how the relationship between faces that are overturned and right side up.

The next step is to remove the sample, making sure that the orientation mark is retained, and taken back to the coreyard/laboratory and reoriented. The best way to do this is to place the sample in a bucket of non-magnetic sand (Figures 2 and 4). Make sure the dip symbol is horizontal and then rotate the sample forward or backwards to duplicate the dip measured in the field. Then rotate the whole bucket until the correct dip direction is achieved.

Figure 4. Re-orientation of the sample using a bucket of non-magnetic sand. As can be seen in the first photo, too many hands are never enough, and peer pressure is important for getting the sample correctly oriented. Note that the sample orientation is written on the sample. It Is good practice to also record the orientation in your notebook, tablet etc as well as on the sample. There's nothing worse than spending a day mapping and then finding out your sample has bounced around in the back of the Toyota and the sample orientation has rubbed off. Note also that the orientation mark is horizontal and that it has then been possible to mark a horizontal line around the sample (Figure 5).

Once the sample is oriented it is a simple matter to use a compass to mark the desired orientations to cut the sample. In Figure 5 below, the sample has been marked up so that a horizontal and a vertical (well, almost – blame the re-orientation crew for this!) face can be made on the sample (Figure 6).

Figure 5 - Sample marked up for slabbing a horizontal (blue) and vertical (red) face.

Figure 6 – All hands on deck for the slabbing process!

If we go back to the sample in Figure 2, we can see two planes have been marked. In Figure 7, the N-S vertical section (blue) has been marked and this could be parallel to a drillhole fence. The other section marked is a horizontal plane (red). The top right-hand cartoon in Figure 7 shows the sample has now been cut parallel to the N-S plane. A vein and a cleavage can be seen on the cut section. The apparent dips of these structures can be transferred directly to the N-S drill section (bottom of Figure 7). Similarly, if a horizontal section is cut, the strike of structures can be directly measured on the sample and transferred to a plan.

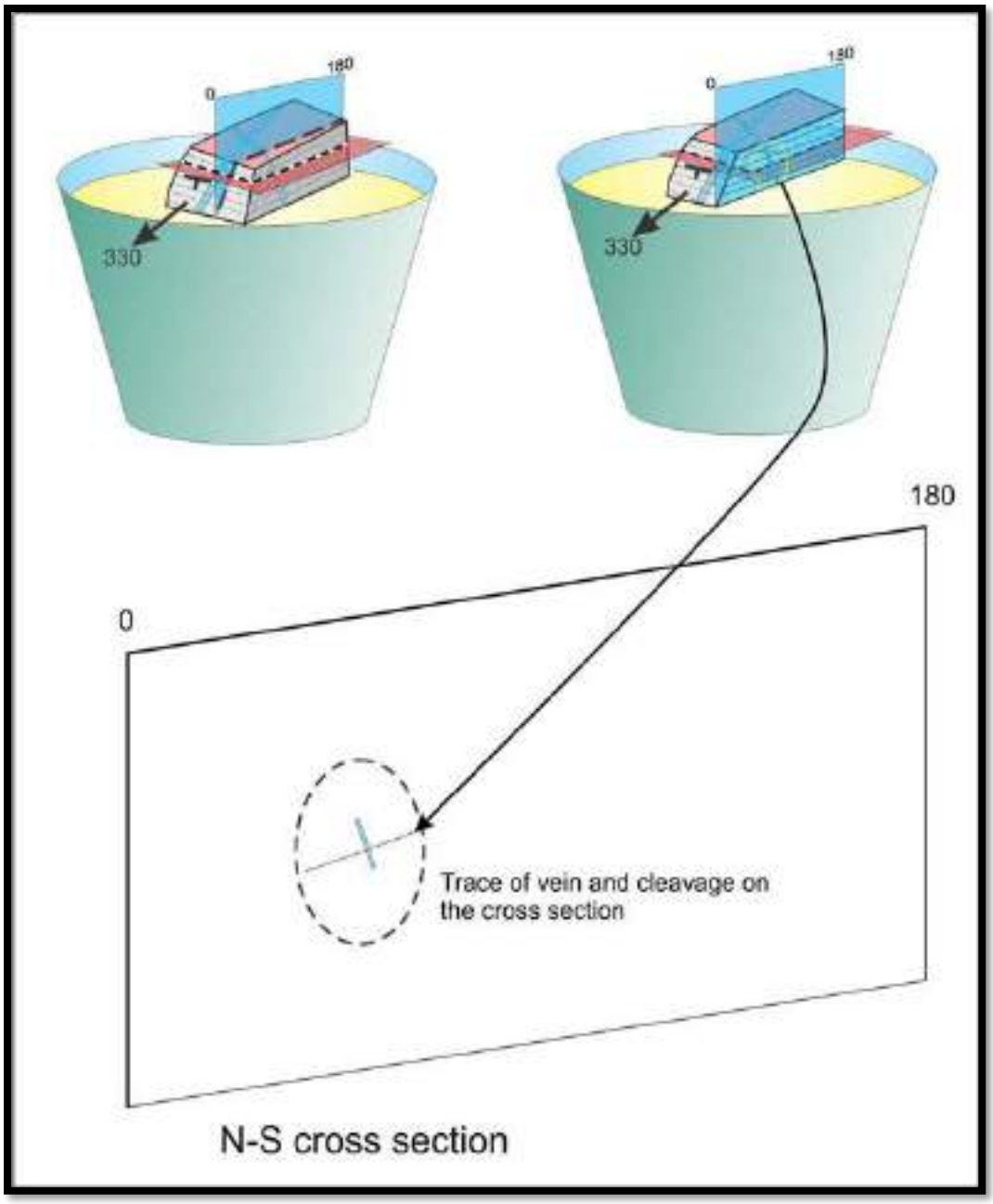

Figure 7 - Cartoon showing how the apparent dip orientation relationships of structures exposed in a cut oriented sample can be transferred directly to a cross section. Similarly, a horizontal slice could be made, allowing strike measurements to be transferred directly to horizontal sections/maps/plans. The sample and contained structures are the same as sketched in Figures 2 and 3.

Oriented thin sections

The obvious progression from reorientation and slabbing of an oriented sample is to prepare oriented thin sections from it. This is because not all fabrics or overprinting relationships or kinematic indicators can be seen in hand specimens. As such, we have to plead to the preparation of oriented thin sections that can then be treated exactly the same as the oriented faces on the slabbed sample.

To do this, the thin section billet location is marked on the slabbed surface, along with the orientation of the surface (Figure 8). If it is a vertical slab, then an asymmetric horizontal arrow is placed on the thin section area, with an indication of the direction where the arrow is pointing (Figure 8). If the slab is inclined, a dip and strike symbol is placed on the billet area, along with the orientation of the face (Figure 8). If it is a horizontal slab, a north arrow is placed on the billet area (Figure 8). From here, the billet is cut out and the procedure is as shown in Figure 9.

Figure 8 – A sample marked up for three differently oriented thin sections. The rectangle in black on the left of the sample is for a vertical section that strikes 000-180 (i.e. a north-south section). The rectangle in white on the right of the sample is for a horizontal section and simply has a north arrow. The rectangle with the black and white numbers at the bottom of the photo is for a section that dips at a low angle to the south.

Once the thin section locations have been marked and the billets cut out, the orientation marks have to be accurately transferred to the glass of the thin section (Figure 9). That way the orientation is preserved if the billet is lost. It is best to scratch this into the glass rather than put it on a label that might peel off. This is summarized in Figure 9 below.

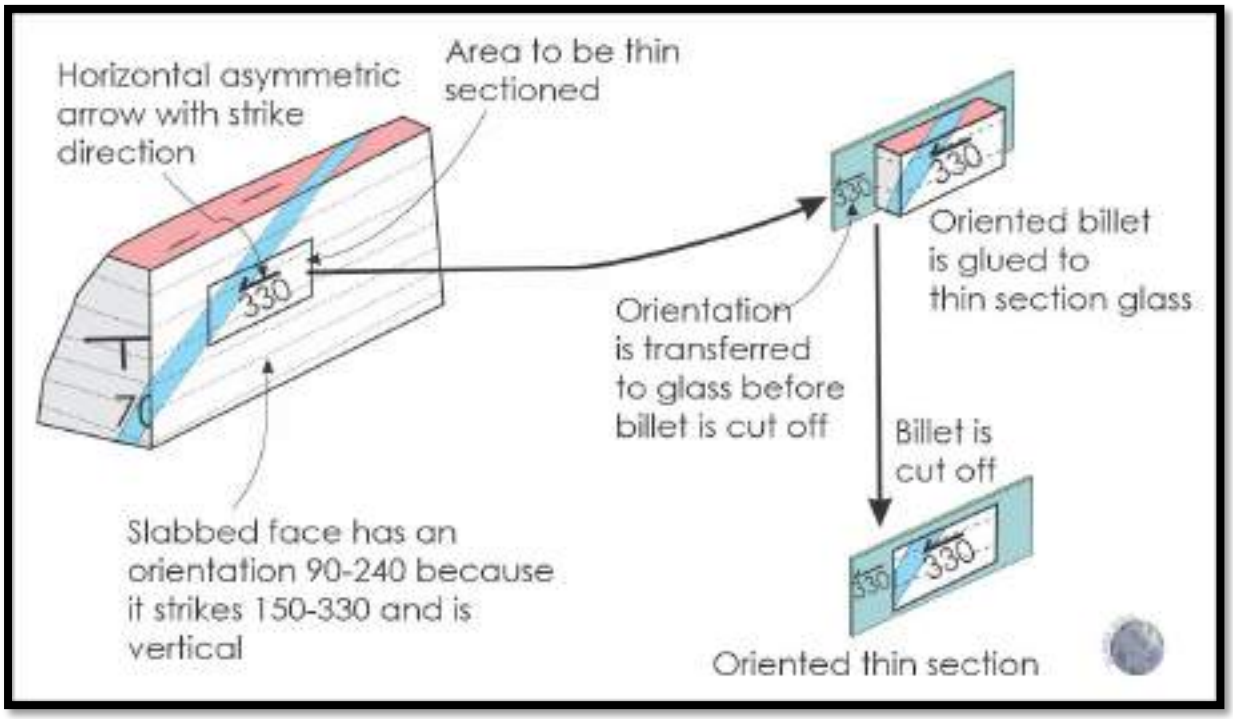

Figure 9 – Summary process for preparing an oriented billet for thin sectioning.

Details of the process of marking the slide are given in Figure 10, which is a diagram that should be supplied to the thin section technician along with the billets. This is because thin section technicians are smart guys and good at their craft but not all of them know how to make an oriented section.

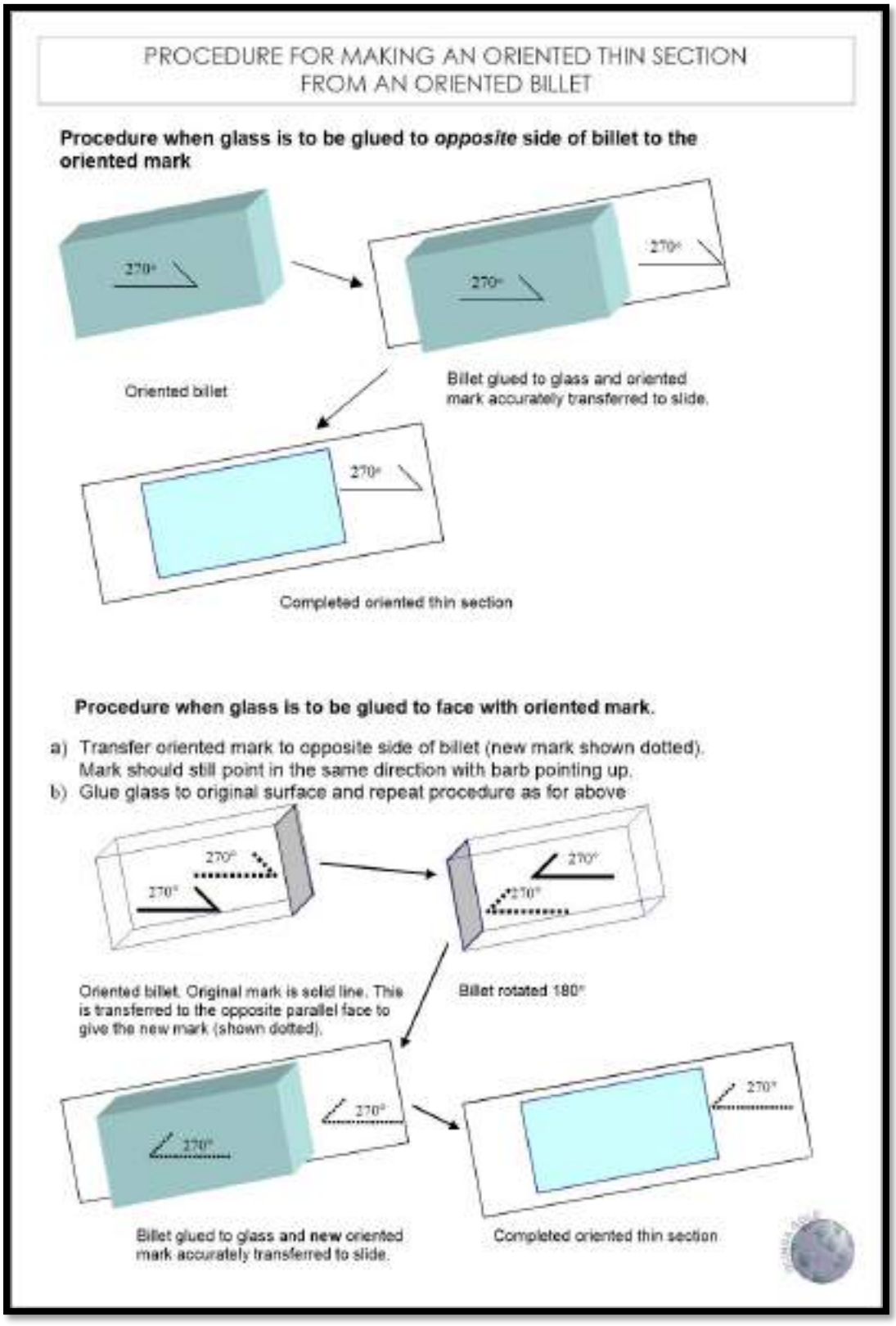

Figure 10 – Detailed procedure for making an oriented thin section from an oriented billet.

An additional step to uniquely identify the billet, as suggested by Lyal Harris, is to nick the billet with the saw (Figure 11), thereby reducing the possibility for error if wanting to re-orient the billet on the slide. In this case, you should ensure that you have all of the billets returned to you with the thin sections.

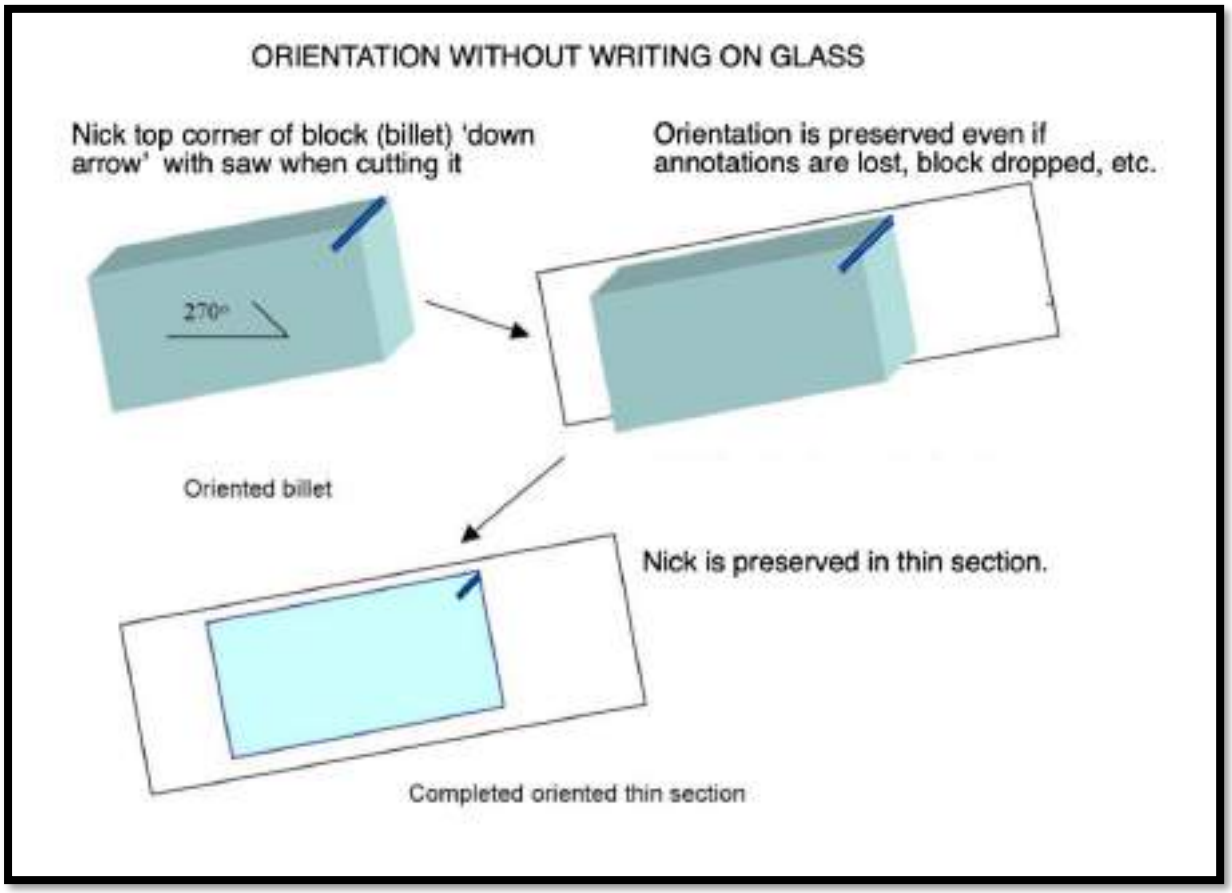

Figure 11 – Additional method for uniquely orienting a thin section billet.

Obviously, core with a flat surface is easiest to use when preparing an oriented thin section. As such, it is typically done on the half-core remaining after sampling. This has the advantage of selecting a sample that will help answer questions that have arisen during logging. As with an oriented hand-specimen, the core is re-oriented using a core orienting frame or bucket of sand (Figure 12). The area to be sectioned is then marked up exactly as for an oriented hand specimen (Figure 13).

Figure 12 – Reorientation of drill core using a core orienting frame or bucket of non-magnetic sand.

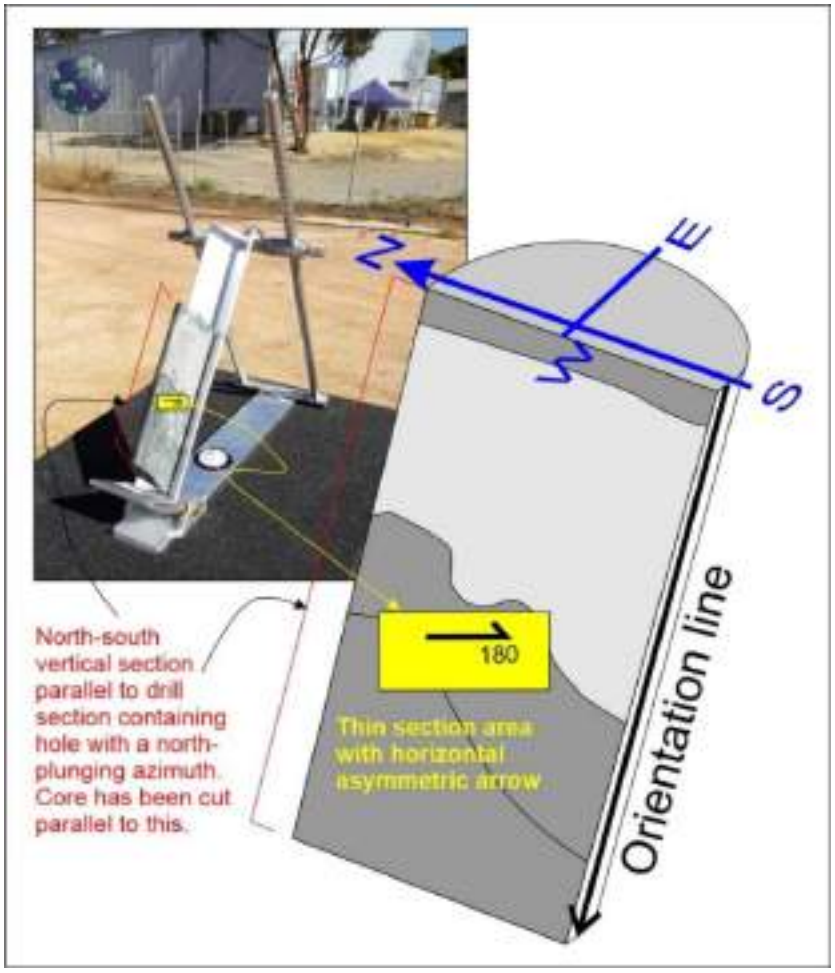

Figure 13 – Mark-up of core for preparation of an oriented thin-section

Oriented samples are a permanent record of structural relationships – my final rant (so far)

As an example of the use of oriented samples, I undertook a seven-month study of the structural controls on gold at the Kanowna Belle Gold Mine in the Eastern Goldfields of Western Australia. I collected over 300 oriented samples during the study, and these were ultimately the only record of the structural relationships in many parts of the mine. Many of the original sample sites were from planned stope development and were subsequently destroyed. The only way structural relationships in the mineralised portions of much of the mine can be revisited is if the oriented samples are used. Despite this, I do acknowledge that there is no accounting for the poor curation of samples. I did a report detailing mine coordinates for each sample, along with the orientations of the samples. This was put in the Kanowna Belle library, and the samples were stored in the Hay St, Kalgoorlie, sample shed that originally belonged to Delta Gold. The premises cycled through several subsequent owners, including AurionGold, then Placer, then Barrick. Only the Flying Spaghetti Monster knows where those samples are now, but I'd be fairly certain some bean-counter or other muppet has thrown them out, and the report has been buried at the back of a sea container somewhere.

As a final note, I would say that it is always better to collect a sample and not need it as opposed to not having a sample at all. In addition, if a sample is collected it should be oriented. It is the same argument as for diamond drilling. If a hole is drilled, then it should be angled and there needs to be a good reason for why it is not oriented. Structural geology may be top of the tree, but geology is a fickle beast, and we need to collect all the information we can. Or you could be like one geologically challenged individual who worked on the same multiply deformed deposit as me and state 'I don't want structure to complicate the deposit', which is effectively the same as burying your head in the sand bucket! I choose to collect samples and data and let the rocks do the talking.

References

Here are the few references on oriented sample collection that I could easily glean from the internet. The video by Tom Argles is very good.

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