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STructure from photographs of ORiented Core: STORC

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Abstract

Measuring the orientation of structures on drill core is laborious. However, the measurements can be carried out with a similar accuracy from high quality digital photographs of drill core. This approach is much faster and has better quality control than manual measurement. Software has been developed that speeds up the measurement of structural data, both planes and lines, in oriented core with only minor loss in precision of measurement. Where high quality drill core images are available, the orientation of planes can be measured at about 2/minute. One area where the improved throughput is significant is in discontinuity analysis for modelling blast fragmentation and geotechnical rock quality. In this case it is important to measure all the joints to define the population spacing. A manual is provided in the supplementary papers. The installer for the software is available from the corresponding author.

Introduction

High quality photographs of drill core are now widely available. Some of these are poorly lit and low resolution (50 dpi). Increasingly, well-lit photographs at better than 100 dpi (<250 micron pixels) are being recorded. At this resolution it is possible to recover the orientation of geological structures such as bedding, joints, veins and cleavage directly from the photographs of oriented whole core if the orientation mark and both sides of the core are visible in the photograph (Fig. 1).

The concept of recognizing structure orientations from core was introduced by McClellan (1948) and Zimmer (1963). Initially the structure was measure directly on the core. These methods were reviewed by Scott and Berry (2004). The concept of measuring these structures from images has been used for about 20 years. Most of the early systems are based on a 360° view of core (e. g. Weber, 1994; Shigematsu et al., 2014). These methods are most appropriate for downhole Tele-Viewer images.

For most ore deposits, core photographs are taken in core trays with only half of the core surface visible. The geometry of these photographs limit the precision of the measurement for structural orientation but they can still be interpreted provided the orientation mark is visible in the photographs. In practice the errors are large if the orientation marks are too close to the visible edges of the core and good results can only be achieved if the orientation line is within 45° of the top of core in the image.

Quiniou et al. (2007) suggested using automatic recognition processes to define the intersection of a plane with the drill core surface. In contrast the method outlined here requires the user to recognize the structure of interest. After the user identifies points where the plane intersects the top (visible) surface of the core, the orientation can be calculated. The x and y position of an intersection can be generated directly from the image. The z value for the intersection can be inferred from the cylindrical geometry of the core. This requires the position of the core to be defined by the margins of the core which must be visible in the core photograph for this analysis to work. If more than 5 points on this intersection are known a least squares method can be used to fit the equation of a plane to the points. The pole to this plane is then rotated to its the real world orientation from knowledge about the direction of the drill hole and the original position (top or bottom of core) of the orientation mark. All of these calculations are simple but tiresome. We have put them into a simple program that can be used to generate structural data from planar structures that intersect the visible core surface. The detailed structure of the calculation is shown in a spreadsheet example in the supplementary papers. The geometry of lines can also be interpreted from core (Scott and Selley, 2004). Provided both ends of the line intersect the visible cylindrical surface of the core in the photograph, the true orientation of the line can be estimated by this software.

STORC is software developed to obtain structural data from photographic images of oriented drill cores. It is a manual system but much faster than measuring joints directly on core. STORC is designed to measure orientation from core images that have pixels sizes around 100-200 microns (better than 125 dpi). Older mine photographs have 500 micron pixels (50 dpi). While STORC can be used with these lower resolution images it will not produce the best results. The aim in this report is to demonstrate the application of STORC as a cost effective way to measure structural data from oriented core. Multiple structures can be measured with annotation. All data calculated is saved to a comma-delimited file. The software is provided as “freeware” available from the corresponding author and a basic user’s manual is included in the supplementary material. Commercial packages that include this capability are Wellcad and Stereocore^{TM}. The aim here is to present a publicly available package which supports rapid analysis of discrete fractures (joints), other planar objects (bedding, veining, intrusive contacts) and lines (fold axes, stretching lineation) that is useful in geological interpretation.

Foliation and joint measurement using STORC

Case 1

The program STORC was used to measure foliation for 500 m of core. Oriented core was used from seven drill holes. The project aim was to find the orientation of a representative population of foliations. In practice, four measurements of foliations were attempted on each core tray. At this sample density the analysis took 3 minute per core tray.

The orientation of foliation measured by STORC is shown in Figure 2A. There is a strong unimodal distribution with a weak spread of the poles around a great circle perhaps reflecting some late gentle folding. For the same drill core interval, the structures recorded in the mine database are shown in Figure 2B. The distributions of poles in these two stereonets are statistically identical and no differences arising from the remote measurement of the foliation was detected. The measurements by STORC are expected to be less precise than the direct measurement method but in this distribution that has not affected the overall pattern of poles to foliation.

Case 2: 100 m of strongly fractured rock.

In underground mining the spacing of joints is as important as the orientation (Annavarapu et al., 2012). STORC is well designed of use in this environment where the oriented core is properly marked for geotechnical work. However parameters such as fracture roughness and infill mineralogy are difficult to determine from the images and where these are important (e.g. Tokhmechi et al., 2011) STORC will be less useful. The images could also be used to estimate RQD and the Geological Strength Index (Marinos et al., 2005) but that is not supported by the present version of STORC.

As an example we have measured all the visible joints in 100 m of oriented core from a site that was being considered as part of an underground mine. In all, 319 joints were measured (Fig. 2C) in 6 hours.

Conclusions

The orientation of planar features such as layering, foliation and joints can be generated from core photographs at about 2 measurements/minute. While this method is expected to be less accurate than direct measurement, no difference was detected in the distribution of a dataset measured using conventional means. The ease of measurement improves QA/QC and the larger number of measurements means a more representative dataset can be generated. The software can also be used to measure lines where both ends of the line hit the upper visible surface of the core.

STORC is particularly useful when a statistically significant number of measurement are required. A user’s manual is included in the digital appendix. A copy of the program installer is available from the corresponding author.

Acknowledgements

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Figures

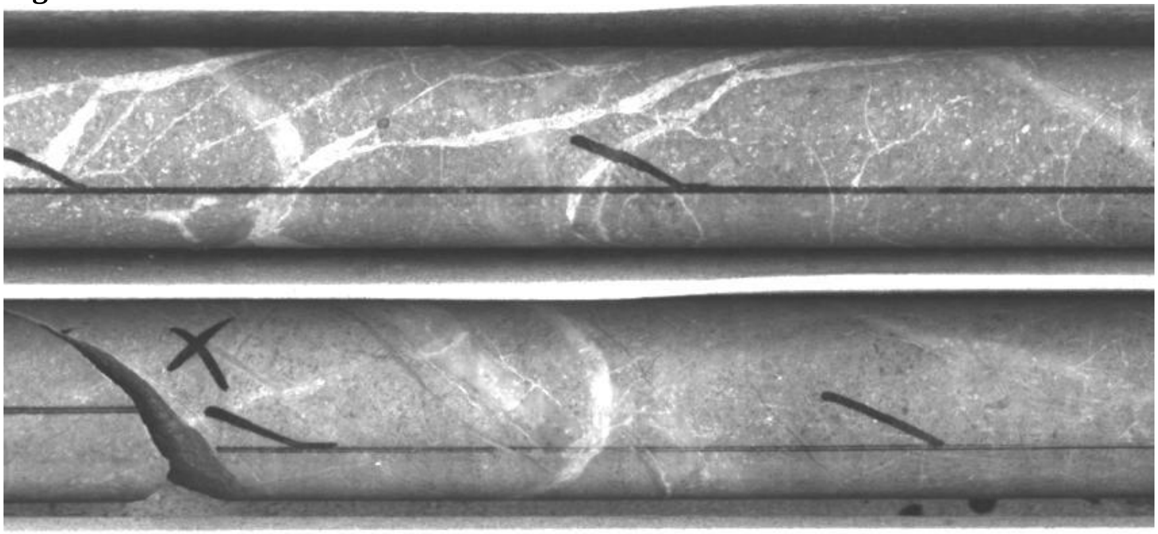

Fig. 1. Photograph of full core showing both sides of the core and the orientation marks.

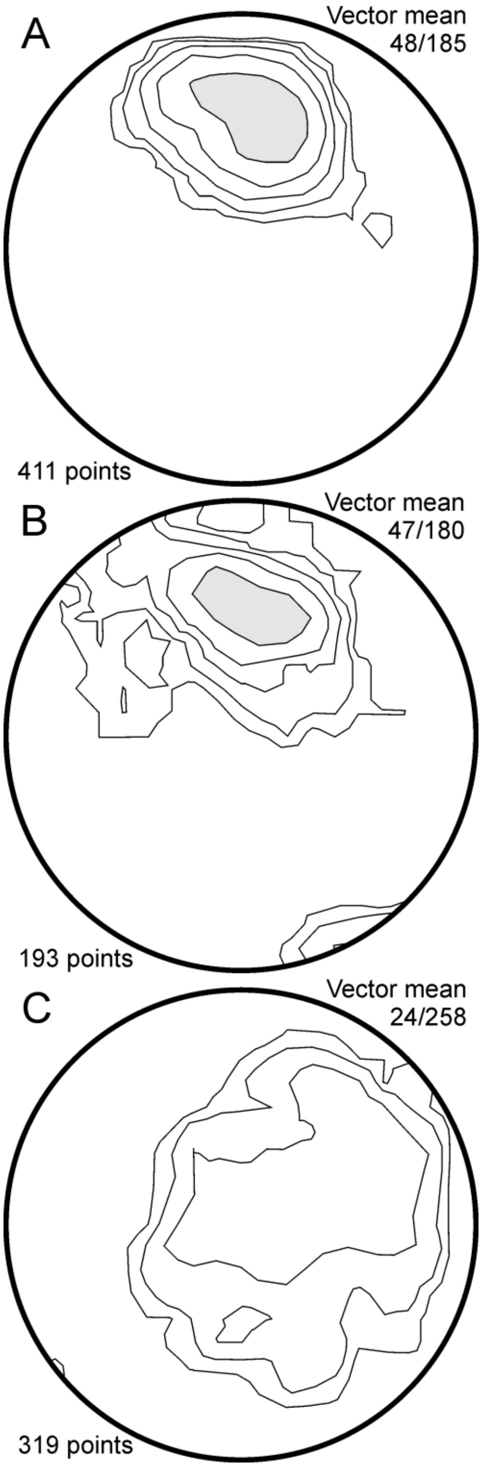

Fig. 2. Lower-hemisphere equal-area stereographic projection of structures. A. poles to foliation at mine site measured using the STORC software. B. poles to foliation, as measured directly from core and recorded in the mine database, for the same interval as measured using STORC. C. poles to joints measured using the STORC software from 100 m of core. Contours at 1, 2, 4, 8 and 16% /1% area. Above 16% contour shown in grey. Contouring carried out using GEOrient (Holcombe, 1994).