

Author(s): Westhoff and others

General comments

I find the paper is interesting and relevant, and worthy of publication. The paper is well illustrated, but could still be improved fairly easily.

First, I suggest inserting very early on a few lines (no more) on why a core deviation and/or a duplicate core might be needed. Incidentally, I would refer to the second core as a ‘duplicate’ and not a ‘replicate’.

Second, I would consider the method-related terminology and stick to it throughout; as written, I have no doubt that the terms are correct, but I was still a little confused by the process (involving milling, cutting, grooving and broaching). I think this comes from a need for a simple (or at least as simple as possible given it is quite mechanically technical) explanation of the process from the outset, followed by consistent use. If I follow the technique correctly, I might suggest a summary something like: “The method is based on adapting the corer to incorporate three key functions. First, a retractable broaching tool cuts a vertical groove, ~30 mm wide and up to * mm deep, along the borehole wall. Second, a spring sleeve, which bows into and slides along that groove, retains the corer in a consistent and known orientation. This spring sleeve also pushes the base of the corer laterally away from the keyway, raising the cutting head’s contact force on the opposite side of the borehole wall. Third, a milling head (with the ability to cut sideways as well as downwards) is used to mill into the opposite side of the borehole wall under this enhanced force.” (Incidentally, one could also refer to the groove as a ‘keyway’, but I’m not sure the technical accuracy outweighs the rarity of the term; ‘groove’ would be good enough for me).

Third, and again if I understand correctly, the reported application demonstrates the use of the technique to create a shelf from which it should be straightforward to core a new hole. However, this duplicate coring is not guaranteed, and the manuscript does not actually report that new duplicated coring. This needs to be acknowledged.

Fourth, several pointers for future improvements, refinements and applications are given at various places in the manuscript – most notably in 2.4.3. However, this is not the only place potential improvements are raised or implied. I would retitle 2.4.3 as ‘Trial application’ and insert a new subsection on ‘Future improvements’ (or similar) into the Discussion or the Conclusions.

Specific comments

| Line/Location | Comment/Suggestion |
|---------------|---|
| 11 | ‘...in the EastGRIP...’ |
| 11- | Here, I think the explanation would benefit from being presented more clearly. It also doesn’t have to be the downhill side – in fact, I think this is a bit of a red herring and I might not mention it here at all. Perhaps mention that the process can be assisted by using gravity on a non-vertical section of borehole. |
| 20 | I’d delete ‘...in the borehole...’ to end of sentence. |
| 24 | ‘The replicate system...’ (and I’d refer to it consistently and solely as a ‘duplicate’ system). Given the two possible uses, I might even refer to it as a ‘deviating/duplication system’ (sounds awful though). |
| 26 | ‘...2500 m...’ (insert space) |
| 38-41 | ‘We performed another test at the NEEM site, in a dry 400 m deep borehole of local inclination ~4°. Here, the inclination was sufficient to mill into the side of the borehole under gravity alone, cutting a quasi-horizontal ledge into the borehole wall.’ (I’d not dwell on this being unpublished, since you are doing so here). |

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| 56 & 105-110 | The manuscript presents little information on this orientation package and the data are also not presented. I think this verification claim does need to be demonstrated in the main text. Alternatively, if the data somehow fall short, at least alternatively refer to 'future application of... But it'll still ideally need a reference, and it would be nice to see the corroborating inclination data. |
| 60-61 | I would put the source attribution in the Figure caption and just refer to 'Supplement 8' at the appropriate point in the text. |
| Fig 2 (& 71) | I'm not convinced this needs to be inclined. Since the technique needs to be deployable anywhere along a borehole (by the manuscript's own requirement section) then a preexisting inclination cannot be a requisite. Also, for me it detracts from the core technique of the spring pushing from the keyway. It also confuses since the application in the manuscript is the other way around... I'd just mention that a pre-existing inclination helps mill into the downhill side (with the uphill side broached) – as long as the orientation is suitable for the need. Perhaps all of 71 – 75 can be reworded to account for this. I would label spring sleeve and ledge on panel C; also the groove/keyway on B. |
| 76 | 'The system needs to comply with certain operational requirements:' |
| 83 | '...diameter.' |
| 84 | The system must operate at... |
| 2.2 Subtitle | 'System deployment and testing' (?) |
| Fig 3 | Are there any orientation data to refine panels H-J? |
| 90 | '..cable tension excursions.' 'g-j) show lateral milling of a ledge in the borehole wall, indicated by...' |
| 105 – 110 | Are these orientation data not available to be shown as a log alongside e.g. Fig 3H-J? See also comment on line 56 above. |
| 120 | '..groove in the borehole wall.' |
| 120 - 123 | Again, this is a slightly different way of describing the technique and process. I would select one description and either not repeat or, if repetition is needed, stick to almost exactly the same wording to avoid any possible confusion. I would also remove the role of off-vertical inclination from the primary description – in the first instance assuming a vertical borehole and only once described noting that an off vertical inclination can help through gravity. |
| 133-134 | We then raised the drill by 20 m and lowered it again. By rotating another 90° (resulting in a total rotation of 180°)... |
| 134-135 | Can the 5 mm deep keyway be explained? Is it that a certain depth of material is removed during each pass? |
| 148 | Move to new future refinements section? |
| 151 | Interesting. Just from personal reference, I imaged what I think must have been a similar helix (I imagine from the normal teeth) at ~170 m depth in the NEEM borehole wall. See Figure 3d here: http://dx.doi.org/10.3189/2013aog64a201 . Happy to share the original if you want it – but I don't think this paper needs it. |
| 157 | 'The spring sleeve is designed to push the milling head into the opposite side of the borehole wall.' (This is simpler and avoids reference to a 'radial' force – which I am not confident of). |
| 161 | 'AT' needs defining |
| 170 | Sampling frequency improvement could be included as a future refinement. |
| 182 | 'During upwards drilling, the blade faces upwards and the chips...' |
| 188 | '...(not plotted). We started...' |
| 190 | '...slow descent and...' |
| 196-197 | I leave this up to the authors, but I think I would remove the effects of this power-outage from the data (and note that it was done); it is clearly an artefact. |
| 200 | 'After milling into the borehole wall...' |
| 205 | '...the ledge, as evidenced by no drop in...' |
| 210 | '...test, possibly by degrading the integrity of the ledge by repeated contact.' |

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| 217-220 | I'm not sure this distinction needs spelling out again – the manuscript already stated that the test was the 'wrong way around'. |
| 224 | A future development to add to the list? Delete '..., which we could not do with our test' |
| 225 | Also need to consider chip removal as a future development since one of the manuscripts stated requirements is to be able to deviate-duplicate at any depth (below casing I imagine). |
| 235 | '... will improve further the effectiveness of this technique by supplementing the force imparted by the spring sleeve with that resulting from gravity.' |