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Earth Surface Dynamics Discussions

Interactive comment on "Ice sheet and palaeoclimate controls on drainage network evolution: an example from Dogger Bank, North Sea" *by* Andy R. Emery et al.

Anonymous Referee #1

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General comments

Very interesting manuscript that presents new results from subsurface mapping at the Dogger Bank. The new results are used soundly by the authors to discuss implications for the geological development in the central North Sea region since the LGM, and for drainage system evolution in general when subjected to environmental changes from glacial to marine. The quality of the data used is generally very high with a dense grid of high-resolution reflection seismic data and many CPTs.

However, some of the figures could be improved to increase clarity and documentation (ex by use of a, b, c, for 'subparts' of figures and with reference to such 'subparts' in

the text) (see more in specific comments) and there are a few issues that could be elaborated (or alternatively omitted):

1) Various links to subglacial valleys discussed or highlighted in the manuscript. These links often appear somewhat contradictory. a. Channel 1 and 2 resemble subglacial valleys in their dimensions and undulating base and the authors show a deeper subglacial valley in Fig. 9 that has a very similar appearance as channel 1 b. On the other hand, the authors argues that there is a lack of subglacial valleys in the study area c. The course of channel 1 is explained by the underlying subglacial valley but it is not further accommodated in the presented model of formation 2) The erosional features at the seabed is not well documented or discussed. Maybe they are the subject of another manuscript in preparation. It would however be good to further document them - e.g. by adding a cross-section to Fig. 9 showing both the subglacial valley and the erosional features.

Listed below are some further specific comments to the text. Despite the many comments, the manuscript is generally of very high quality. It is very well written, with a logic structure and a clear focus, and it represents a great contribution to geological research of the Dogger Bank.

Specific comments Line 65- 81: How certain are the ages provided? 23 kyr BP, 8 kyr BP Line 80-81: "..buried during subsequent marine transgression around 10 ka". This contrasts Fig. 8 where marine transgression is stated to happen at ca. 9 ka BP Line 95: Is it multichannel or single channel reflection seismic data? Line 98: Was a bandpass filter the only processing carried out? Seems a bit too little to do on data if they are multichannel sparker data. If single channel data - ok. Please clarify. Bandpass filtering can also be done in IHS Kingdom Suite Line 100: state velocity used for calculation of vertical resolution in meters. Line 103: Please clarify how you derived the velocity from the geotechnical data (CPTs) – or refer to Cotterill et al 2017a here also. Line 105: the grid cell size of 10 m x 10 m appears to be a bit small (at least for the 'across' line direction) considering that your line spacing is

at best 100 m. Please elaborate on the choice of cell size. Maybe by including the horizontal resolution of the seismic data (inline direction)? Line 106: which further processing in QGIS is referred to here? Specify. Line 113-116: you have used cone resistance as a proxy for grain size. Did you calculate soil behavior type index? Or plotted cone resistance to friction ratio (classic Robertson diagram)? Did you normalize and correct the measured values for pore pressure and burial depth? Please specify. Line 118: Why not just do this in Kingdom Suite? Line 119-120: "Using this method the upstream. . ." What do you mean by this sentence? Elaborate Line 121: UTM31N - consider to also state the geodetic datum. WGS 84? Line 125: Please consider the uncertainty related to the gridding at 10 m cells here. In principle only every 10th point would be data based if the channel direction was perpendicular to your inlines (with line spacing of 100 m). Line 127-143: The two models are significantly different from 26 to 18 ka BP. It is hard to provide better modelling, as the authors stress, but the uncertainty for this period and the potential for other environmental interpretations should probably be considered in more detail. Line 149: Please highlight horizon Z in the lower panel of Fig. 1. Line 151- 157: Refer to Fig. 2 Line 153 and elsewhere: Consider to use 'reflections' and not 'reflectors' for what you see on the seismic cross-sections. Reflectors are the physical boundaries in the subsurface while reflections are the geophysical representations of these reflectors. Line 165: reference to one of your figures (e.g. Fig. 4b?) Line 235+316+368: very hard to see these low-relief valleys from the maps you have presented. Do you just mean the centerline of the main channel segments or do you mean wider valleys in Horizon Z? Specify or show better on figures (i.e. use another color scale for the grid of Horizon Z). Line 237-238: consider to refer to Prins & Andresen (2019) that discuss a subglacial valley origin of their river channels. Line 238-239: consider to refer to the Ottesen et al 2020 on tunnel valleys in the North Sea (https://doi.org/10.1016/j.margeo.2020.106199) Line 236-243: In this section you present your interpretation of the channels as fluvial rivers. The dimensions and stratigraphic position of the channels and the lack of deformation of underlying sediments are presented as arguments for the fluvial origin. However, the

similarity in terms of dimensions, between channel 1 and the underlying subglacial valley (Fig. 9) is not accounted for here. Could this similarity support a later ice-sheet readvance for initiation of channel 1 and 2? Elaborate. Line 264: for consistency, use 'channel-fills' instead of 'channels' here. Line 271-272: How can you see that the dipping reflections are downstream? It appears that the cross-sections you show are mainly across (perpendicular to) the channels and not along. Maybe you have other lines showing the downstream direction better? Please refer to a specific figure here (e.g. Fig. 4c) Line 275: 'streams' not used previously. Maybe better just to stick to the 'tributary' term Line 280-281: deepest point. Depth measures relative to mean sea level or? Consider to add a remark on the uncertainty in the grids and the undulating basal profiles Line 282-283: Not always easy to see from Fig. 7, that the tributaries steepen towards the confluence of the main channels. Line 314-315: Consider to add a cross-section to Fig. 9 where you show the deeper subglacial valley and the erosional features at the seafloor. This would make your argumentation stronger Line 316-317: How does channel 1 fit into this argument? Line 345: please specify which CPTs in Figure 3 Line 358-363: the lack of tunnel valleys does not fit with your own observation of a subglacial valley (Fig. 9). Please include in your argumentation. Line 374: please highlight these flat areas on your figures (ex fig. 4 or 6?) Line 377: consider to use another wording than 'best' Line 395-396: Show these erosional features on a cross section – maybe as add-on to Fig. 9. Would be interesting to see how they look in order to assess the interpretation as tidal scours. Line 415: consider to add Bølling-Allerød in brackets after 15 ka BP. Line 416-439: The very large differences in the two model runs from 26-18 ka BP are partly discussed and accounted for in the text. However, it would be good to further describe the uncertainties in the two models – and in turn the uncertainties for the presented environmental interpretations. How would a more humid environment from 26-18 ka BP fit/change your model of formation. Line 450-455: Description does not fully match what is shown in Fig. 11. Line 450: westward instead of eastward?

Fig. 1: Subdivide into Fig. 1a (map) and Fig. 1b (seismic cross-section and interpre-

tation). Highlight Horizon Z and sub-unit 1,2,3 in b). Comment on the incision in the seabed. Is this the erosional feature discussed later or? Fig. 2: Subdivide into Fig 2a (facies map) and Fig. 2b (Isopach upper seismic unit). Please add location of seismic line shown in Fig. 1b on both Fig. 2a and 2b. Add outline box for location of Fig. 9. Caption: A bit confusing with the formulation "subcrop map of the major basal seismic unit facies" Consider to rephrase to "seismic facies of the basal seismic unit subcropping Horizon Z" Fig. 3: Very busy figure. Subdivide into Fig 3a (map) Fig. 3b (seismic cross-section) and Fig 3c: (CPTs). Map (Fig 3a): Why data gap in map? - Briefly explain in figure caption. Add outline boxes for Fig 4 and 5 maps. Hard to read CPT names – consider to use white box background. Hard to see location of section A-A' CPTs (Fig. 3c): Consider to reorder the shown CPTs to a more logical arrangement. Ex sorted by penetration of main channels or tributaries, or no channels. Please place the name label for the CPTs consistently in one area of the logs. Fig. 4: Subdivide into Fig 4a (map), Fig 4b (cross-section A-A') Fig 4c (Cross-section B-B') Map: add location of Fig 3b cross-section. Add CPTs. Explain white dashed lines Fig. 5: Subdivide in to Fig 5a (map), Fig 5b (cross-section A-A') Fig 5c (Cross-section B-B') Map: add CPTs Fig 5b+c. hard to see whether it is the dark or pale green color shown. Highlight in caption. Fig. 6: Add outline box for map shown in Fig. 9. Where is IC3? What about unnamed ICs (north of Channel 1) Fig. 7: Use subdivision a, b, c, d, e. a, b: Concerning the number of channels analyzed a bit more explanation would be good. The six isolated channels probably is IC1,2,4,5,6,7 which is ok but should be specified for the reader in the caption, The number of tributaries is 8 but I can only count 7 on the map in Fig. 6. Please clarify. c, d, e: Please clarify what OD is (elevation (m OD)). Hard to see steepening into main channels for all of the tributaries Fig, 8: Green colors are here used for proglacial lake fill. A bit confusing when comparing to the cross-sections where green colors are used to indicate channel fill. Consider to change or show a legend for the colors. Fig. 9: Please comment on the fact that this tunnel valley has similar dimensions as channel 1 – meaning that dimensions may not be a valid argument for a fluvial origin of your channels. The 'lack of subglacial valleys in the area'

argumentation should take into account your own subglacial valley. Please include a cross section to show the tunnel valley and the erosional features Fig. 11: Subdivide into 11a (Map) and 11b (timing of events). Map: directions of drainage outlets do no match what is stated in the text. Ex: Paleo-Ems (Hepp et al 2019) goes into EPV. Add channels from Prins & Andresen (2019) instead of just study area.

Technical corrections Line 4: Include F. in author name Ruza Ivanovic to match what is stated in acknowledgement line 504 Line 119. New sentence after 'truncated'. So "...forms where underlying reflections are truncated. Using this method..." Line 502: Include these shape-files of the channels from Prins & Andresen (2019) in Fig. 11a

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