Carbonate cemented pillars on Nesøya: A reply

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This is a reply to a comment 'Carbonate cemented pillars at Nesøya, North Norway: Proposal for an alternative model of formation' by Martin Hovland, initiated by the paper 'Lithified Holocene shallow marine carbonates from Nesøya, North Norway' published by the present authors.

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Pillar-like structures consisting of beach gravel, mainly of calcareous skeletal fragments cemented by Mg-calcite, have recently been recorded by us from Nesøya, Nordland (Nagy & Dypvik 1984). In that paper we proposed a model which explains the formation of the cemented carbonate gravel by a beach rock related mechanism. Hovland (1985) did not find this model satisfactory and claimed that our paper fail to provide a convincing explanation.

One of Hovland's arguments against our model is that he would not expect precipitation of carbonates in reducing sea water environments. We find this surprising, and it is also hard to understand how this beach of carbonate gravel could represent anything but oxic conditions. In this intertidal environment, waves and currents would constantly rework the sediments, carry away the fine-grained material and supply the coarse sediments with ventilated, oxygen-rich water.

Hovland claims that an active hydrogeological environment has resulted in artesian supply of carbonate-rich solutions through cracks and fissures in the underlying bedrock of gneiss. We have no difficulties in accepting that in some cases carbonate-enriched artesian waters may have produced carbonate cement, e.g. as at Islay, Scotland (Adams & Schofield 1983) referred to by Hovland. However, by applying an artesian model to Nesøya several problems arise:

- An artesian system should be present, which is not the case at the locality discussed.
- The occurrence of a calcium carbonate source is required in the basement. The presence of such a source is difficult to imagine on Nesøya, an island consisting exclusively of pyroxene quartzmonzonite and pyroxene monzonite.
- The morphology and composition of the cement should most likely be different from that of the high Mg-calcite and aragonite needles found in the pillars on Nesøya.

The presence of a hydrological environment capable of transporting mineral-rich liquids from the bedrock and up to the beach deposits is proposed by Hovland on the basis of a photograph included in the paper of Nagy & Dypvik (1984, Fig. 5). According to Hovland, the lithified pillar shown in this picture is situated over a crevasse in the bedrock. This pillar, however, actually stands on the margin of an area covered by large beach boulders, where an assumption of crevasses is strongly speculative.

Hovland (1985) also refers to his own observations from the North Sea, suggesting that a similar formation mechanism, by expulsion of liquids and gases, could be applied to the lithified beach deposits of Nesøya. In this connection it is of interest to note that recent carbonate cements from the Sleipner Field (Fig. 1A and B) have a sparitic, low Mg-calcite composition. If Hovland is referring to that kind of carbonates, both their morphology and mineralogy are in clear contrast to those of the Nesøya carbonates (Fig. 1C). It is difficult for us to imagine that different minerals with diverging morphologies are formed by the same processes and similar types of solutions.

In his alternative explanation, Hovland (1985) claims that carbonate cementation could take place above the crevasses, resulting in carbonate

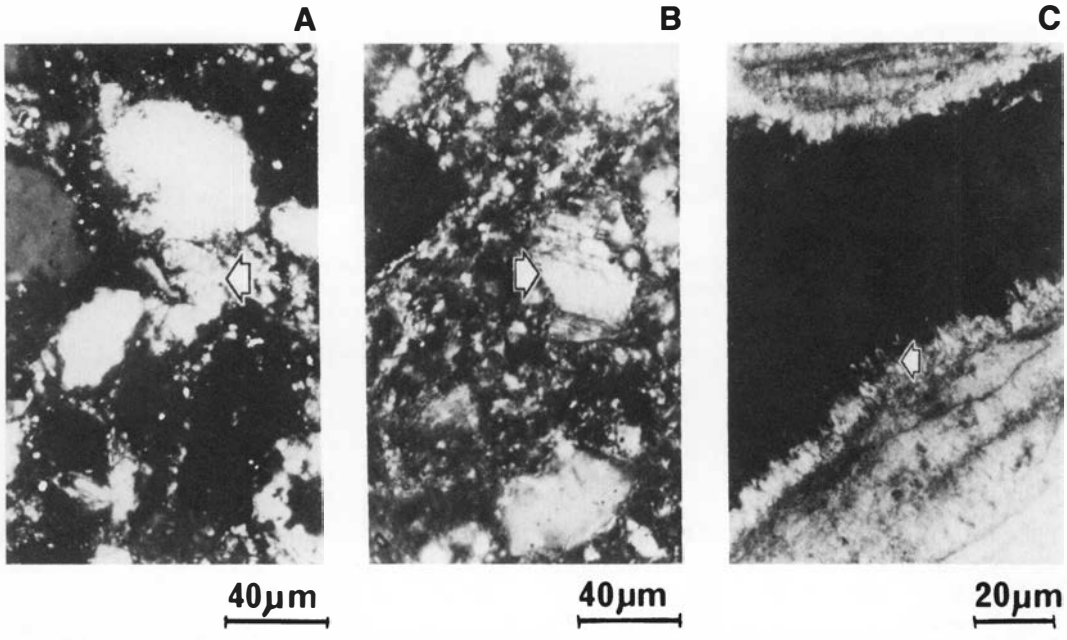

Fig. 1. Thin section micrographs of recent, carbonate cemented sediment from the Sleipner Field, North Sea (A and B) and lithified shallow marine carbonate from Nesøya (C). Arrows indicate cement consisting of low Mg-calcite from the Sleipner Field and high Mg-calcite from Nesøya.

cemented units with 11–21% porosity, surrounded by high porosity/permeability gravel. According to this hypothesis, the artesian water would follow the already cemented pillar shaped body and cement newly deposited beach gravel to its top. In this way a lithified column should develop in the beach sediments. We feel that in a case of fissure-dependent influx of artesian water to a gravelly beach, the main path of the water should not be through the less permeable, less porous, already well cemented pillars, but through the loosely packed surrounding gravel with porosities of about 40%. Would not the development of a cemented gravel lens or bed be the more likely, and a pillar the less likely result?

The artesian cementation model requires that the hydrogeological system is combined with a carbonate source. In the area under discussion such conditions have not been found, and therefore we have to leave out cementation by an artesian mechanism. With this background, we feel that the explanation presented by Nagy & Dypvik (1984) gives a more adequate formation model for the Mg-calcite cemented beach gravel on Nesøya.

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