A Reply. Origin of Limestone Nodules in the Lower Palaeozoic of the Oslo Region

KNUT BJØRLYKKE

Bjørlykke, K. A reply. Origin of limestone nodules in the Lower Palaeozoic of the Oslo Region. *Norsk Geologisk Tidsskrift*, Vol. 54, 397–399. Oslo 1974.

Knut Bjørlykke, Institutt for geologi, Universitetet i Oslo, Blindern, Oslo 3, Norway.

The terms nodular limestone and limestone nodules have been used to include several types that are of genetically different origin. There is no doubt that concretionary processes are capable of forming carbonate nodules, and in many types of sediments this seems to be the most likely explanation.

In the present author's opinion the term concretion requires a more precise definition; it is important to distinguish between concretions that form by carbonate precipitation in an essentially clastic matrix and those formed within a carbonate-rich matrix. Isolated nodules with septarian structures in a shaly matrix are also found in the Oslo Region, and these are most probably formed by concretionary processes. These are, however, not the most common types of carbonate concretions which are discussed in my paper.

Jan Šrámek argues on the basis of my paper that the nodules described from the Oslo Region should be interpreted as early diagenetic concretions and mentions a number of features that he considers strongly disprove dissolution.

In my opinion early diagenetic dissolution plays an important part in the formation of the limestone nodules of the Oslo Region, and I fail to see that there is positive evidence against this theory.

In the following I will try to answer the objections raised by Šrámek.

Firstly, most limestone nodules are not spherical as assumed by him, but generally have rather irregular shapes as it will appear from fig. 1 in my paper. In the case of the large nodules in the Upper Cambrian limestones, their near spherical shape is often due to secondary precipitation of coarse sparry calcite (anthraconite) (fig. 3), which cannot be regarded as a normal concretionary process.

Lamination passing through the nodules is observed in some cases (fig. 8). This relation between the nodules and their matrix may, however, be expected both in the case of concretionary and dissolution processes.

The chemical composition of the Cambrian sediments (fig. 4) shows that the Cambrian limestone beds and nodules normally contain between 80 and 100% $CaCO_3$, while the shales are generally devoid of carbonate. These are facts that in no way contradict dissolution of carbonate. On the contrary the carbonate content exceeding 90% $CaCO_3$ in many nodules is higher than the maximum primary porosity, indicating that these nodules were formed by carbonate cementation of a host rock that already consisted mostly of carbonates. We are here dealing with the cementation of carbonate mud containing abundant trilobite tests, and in that there is no difference between the nodules and the continuous limestones.

The evidence indicating subsolution of carbonates in the Cambrian sediments is on the other hand quite strong. The fact that fossils with carbonate tests, mainly trilobites which are very common in the nodules, are absent or only preserved as non-calcareous casts in the shale around the nodules is direct evidence of dissolution. It is natural to assume that the shelly fauna now found in great abundance in the carbonate nodules originally must have extended as a continuous layer which has later been subjected to dissolution except within the nodules. Alternatively one would have to assume that the trilobites accumulated in isolated pockets on the muddy sea floor. This is inconsistent with evidence of low energy environments in the Upper Cambrian sediments in the Oslo Region (K. Bjørlykke 1974).

Šrámek suggests that many of the more or less discontinuous beds in the Ordovician nodular limestones appear to be concretional lenses and layers developed by coalescence of neighbouring bodies. As pointed out in my paper, all transitions are found between discontinuous nodular beds and limestone beds that are continuous for several metres. If these almost continuous carbonate beds should be referred to as concretions there is a need to define this term more precisely. Cementation of carbonate beds is a normal process of lithification. Only when this lithification takes place by precipitation of carbonate cement in a concentric manner does it seem reasonable to use the term concretion. There may however have been an irregular or patchy submarine cementation which later due to differential compaction may have contributed to the nodular appearance.

There is no direct evidence to suggest that the carbonate beds have developed as a result of coalescence of smaller nodules, and concentric structures are generally absent.

Fig. 2 in my paper (K. Bjørlykke 1973) shows a calcarenite bed displaying a sharp erosive and undeformed contact with the underlying nodules. This figure was included to demonstrate the early diagenetic formation of the nodules, and since the erosional contact was undeformed, boudinage could not have played an important part in the formation of these nodules. As mentioned by Šrámek, nodules can obviously be eroded and washed out from their matrix, but in this case the contact relations between the nodule, the matrix and the overlying bed suggest that the nodules are in place and that they were still soft at the time of erosion.

The Lower Palaeozoic limestone nodules of the Oslo Region have been deposited in an environment characterized by very slow sedimentation of the order of a few mm/1000 y. This must be attributable to a slow rate of carbonate mud production by algae and partial dissolution of the carbonate deposit.

The basin must therefore have been starved both with respect to clastic and carbonate sediments. The formation at nodular limestones can be regarded as a response to this environment.

August 1974

REFERENCES

Bjørlykke, K. 1973: Origin of limestone nodules in the Lower Paleozoic of the Oslo Region. *Nor. Geol. Tidsskr. 53*, 419–431.

Bjørlykke, K. 1974: Depositional history and geochemical composition of Lower Palaeozoic epicontinental sediments from the Oslo Region. *Nor. Geol. Unders. 305*, 1–81.

Šrámek, J. 1974: A comment. Origin of limestone nodules in the Lower Palaeozoic of the Oslo Region. *Nor. Geol. Tidsskr. 54*, 395–396.