Journal of the National Museum (Prague), Natural History Series
Vol. 179 (13): 139-145; published on 10 September 2010
ISSN 1802-6842 (print), 1802-6850 (electronic)

Silicification of fossils in the Silurian and Devonian of the Barrandian, Czech Republic

Michal Mergl

Department of Biology, Faculty of Education, University of West Bohemia in Plzeň, Klatovská 51, CZ-306 19 Plzeň, Czech Republic; e-mail: mmergl@kbi.zcu.cz

ABSTRACT. A report on mode of preservation and distribution of the silicified fossils in the Silurian and Devonian of the Barrandian is presented. Four modes of silicification are distinguished that affected mostly calcitic, less commonly aragonitic and high-magnesium calcite, shells and skeletons; some shells display remarkably small details. Perspectives of the search for these fossils are discussed.
KEYWORDS. Silicification of fossils, Silurian, Devonian, Barrandian, Czech Republic

INTRODUCTION

Silicification of fossils in sedimentary rocks of the Barrandian is poorly explored (Havlíček 1998). During the past ten years, the intensive author's search for phosphatic fossils in Silurian and Devonian limestones led to the discovery of several localities with silicified fossils (Mergl 2003). These results indicate that there are new possibilities for study of small fossils and their morphological details that are otherwise undetectable with classic methods. Below I review the types of silicification and present guidelines for the search for silicified fossils.

MATERIAL AND METHODS

Various types of limestone have been studied from different localities (Mergl 2003). No old collection has been included in this research. Samples of 1-2 kg were mostly used, but one exceeded 100 kg. The rock was dissolved in 10 % hydrochloric acid or 5-15 % acetic acid. The samples were then washed by gently running water. Some samples containing larger skeletal parts were sieved and dried. Fine residual material has been left unsieved and slowly dried in Petri dishes. Structures of small silicified fossils have been studied in SEM. Figured specimens are deposited in the palaeontological collections of the University of West Bohemia at Plzeň (PCZCU). All photos are by the author.

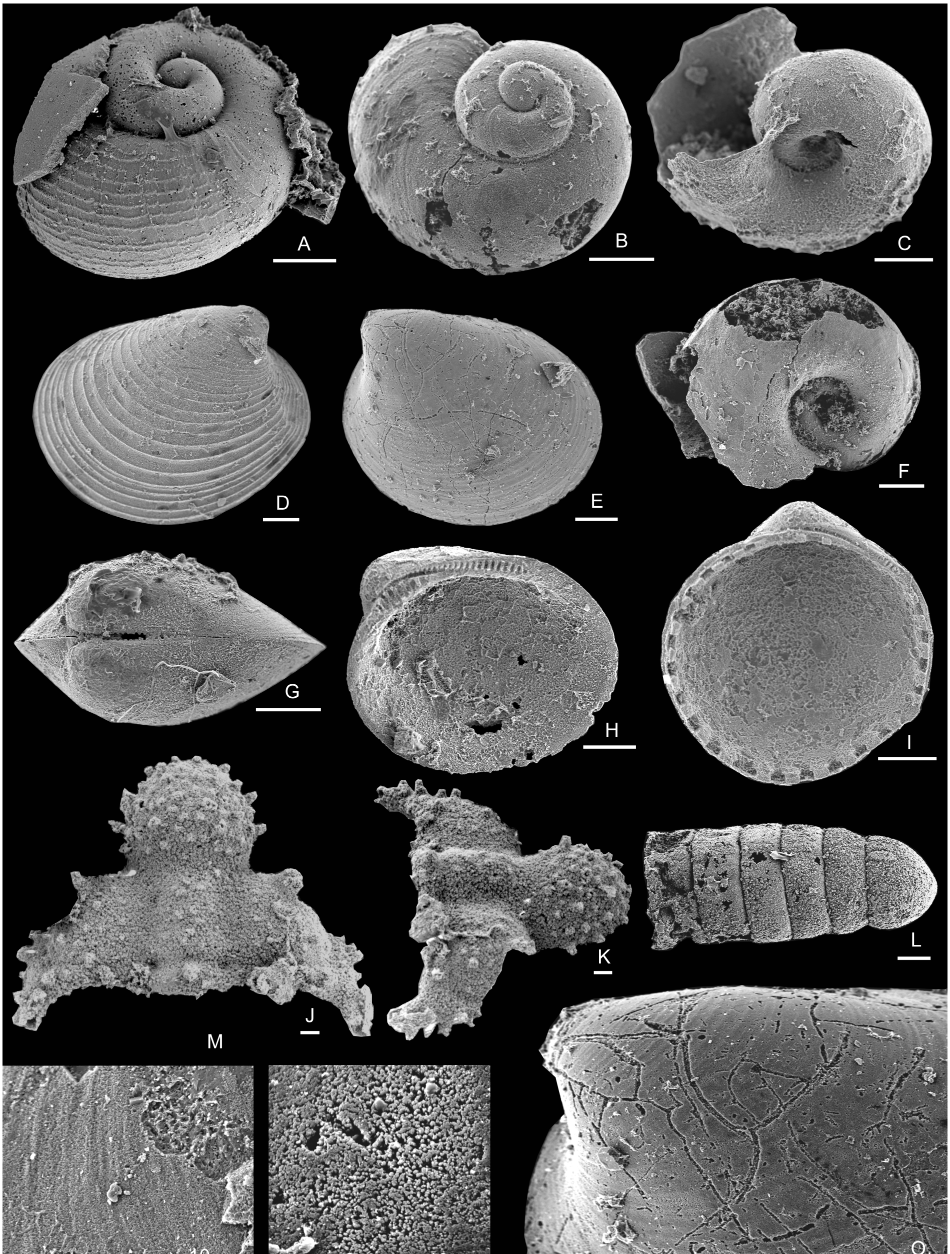

Fig. 1. A – Massive microcrystalline silicification: gastropod shell, Chýnice Limestone, Bubovice, Čeřinka ridge. B–O – "Sandpaper" microcrystalline silicification: B – gastropod; C, F – bellerophontid gastropods; D, E – bivalves; G – bivalve shell showing a gap between teeth; H, I - interior of bivalve shells; J, K – cranidium of trilobite *Staurocephalus*; L – juvenile cephalopod shell; M – exterior showing growth lines with calcite crystals imprints on shells

RESULTS

I recognized four types of silicification, as follows.

(1) "Sandpaper" microcrystalline silicification

This type of silicification is characterized by a preservation of very fine details, including structures of micrometric size. Silica crystals are usually about 1-2 μm in size, or even smaller. Silicification usually affected whole shell wall or skeleton with the exception of the most external superficial layer. Therefore, any external details are rarely seen (Fig. 1M). External and internal surfaces of shells and skeletons are uneven, often with variable, seemingly porous structure ("sandpaper structure"), consisting of densely packed microcrystalline silica clusters (Fig. 1N). Clusters could obliterate very fine superficial details but main structures (Fig. 1H, O) are always preserved. Long superficial extensions of skeletons and shells (thin and long spines, lamellose structures) are not always preserved being often broken and only their bases are preserved (Fig. 1J, K). Fine internal structures (septa, brachidia) are covered by clusters of clay gains that camouflage their original shape and size. Although some fine internal structures are imperfectly or incompletely silicified, the silicification often affects an entire shell (e.g. entire bivalve shells, entire crinoid ossicles). The shells are very fragile.

I observed this type of silicification in various skeletons, including shells and skeletons originally from calcite (trilobites, ostracods, bryozoans: Fig. 1J), high-magnesium calcite (crinoids) and aragonite (bivalves, gastropods, cephalopods: Fig. 1B-I). There are not any significant differences in the quality of silicification depending on the original mineral composition and their biofabric. Skeletons and shells are up to ca. 2.0 mm in size. No entire larger shells were found in the studied samples. This type of silicification has been observed in ostracods, trilobites, gastropods, bivalves, cephalopods, bryozoans, tabulate corals and crinoids. It is known exclusively from bioclastic limestones of the Motol Formation in limestone layers at Kosov Quarry (Section no. 767: Kříž 1992) and Lištice (Section no. 759: Kříž 1992).

(2) Massive microcrystalline silicification

This type of silicification is characterized by preservation of very fine details, including structures of micrometric size. Surface of shells and skeletons are compact of microcrystalline silica. Very fine details are preserved, including growth lines and early spiral lines in gastropod shells (Fig. 1A). Silicification is sometimes imperfect; some shell parts are not silicified or additional silica aggregations camouflage shell shape. This type of silicification has been observed in originally calcite (rugose corals) and aragonite (bivalves) shells and skeletons. Size of skeletons with this silicification ranges from 0.5

←

surface; N – microcrystalline silica of the shell wall; O – microbial borings in silicified shell. Bar length is 100 μm except of N, M where length in μm is marked by a number. All shells are from the Motol Formation, Kosov Quarry.

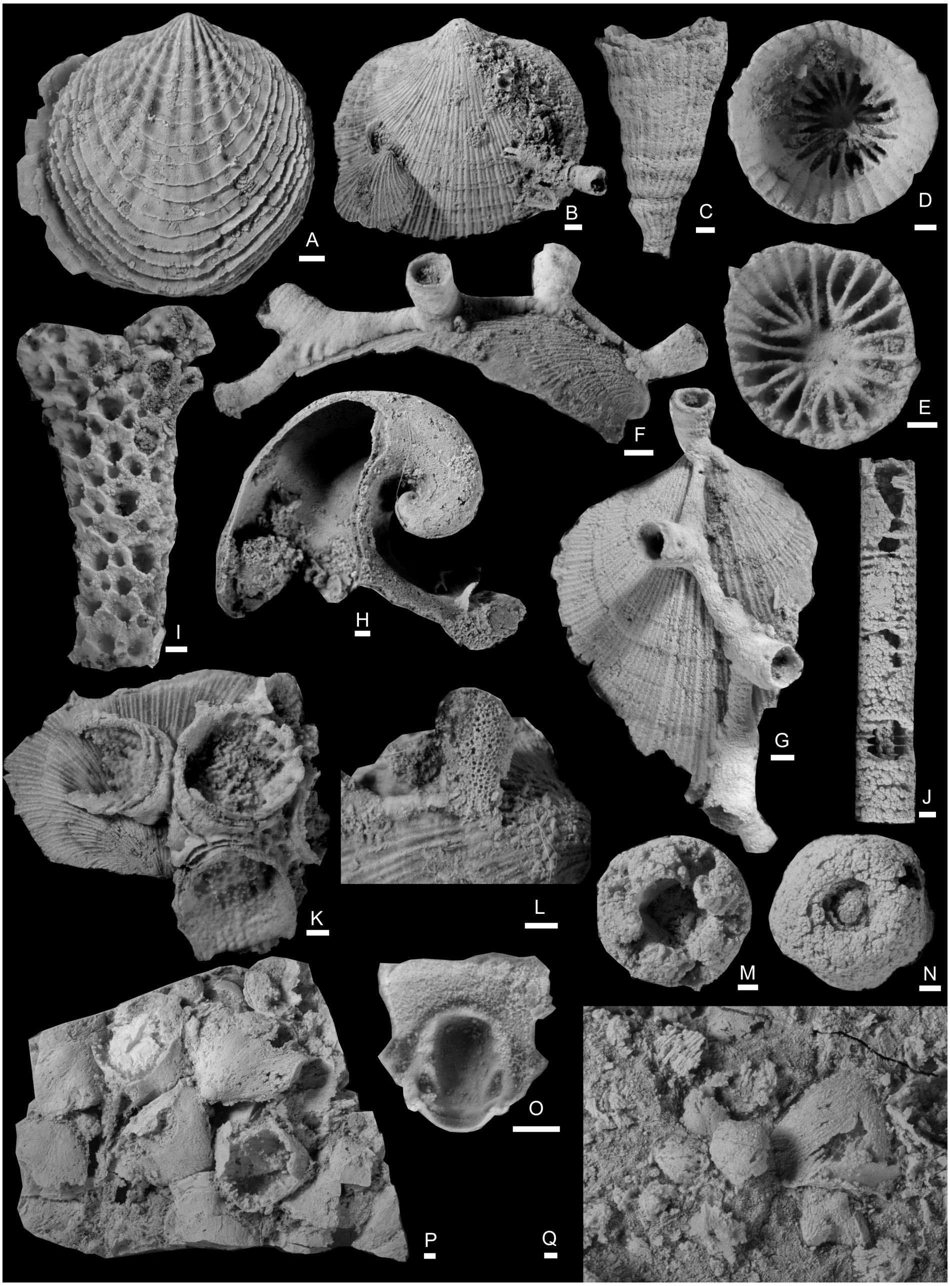

Fig. 2. A–N Massive silicification: A – atrypid brachiopod *Spinatrypa*; B – orthid brachiopod *Isorthis* with attached juvenile *Dalejina* and coral *Aulopora*; C–E – rugose coral; F,G – encrusting coral *Aulopora* on a brachiopod shell; H – platycerid gastropod; I – favositid coral; J, M, N – stem and calyx of a crinoid *Pisocrinus*; K – encrusting rugose coral; L – encrusting trepostome bryozoan; all from Kotýs Limestone, Lochkov Formation in

to approximately 5 mm. Larger skeletons show imperfect patchy silicification. I observed this type of silicification in gastropods, bivalves, trilobites, and imperfectly also in rugose corals, crinoids, and brachiopods. It is known from red micritic limestone with coral tufts of the Chýnice Limestone (summit of the Zlíchov Formation, early Emsian) from the Čeřinka ridge at Bubovice. Similar preservation was found from single layer of grey crinoidal limestone of the Kotýs limestone (Lochkov Formation, Lochkovian) near Bubovice (Branžovy Hill) (Mergl 2003).

(3) Massive silicification

This type of silicification is characterized by preservation of details larger than 0.2 mm. Fine details of micrometric size are missing, being obliterated by silicification. Silicification of shells began from multiple centres. Silica was first precipitated in concentric rings subsequently forming quadrangular zones. These concentric structures consisting of microcrystalline silica aggregates of 0.1 to 1 mm size are commonly preserved in thicker parts of shells (Mergl 2003: Pl. 5, fig. 14). Similar so-called bee-kite rings were reported by other authors on brachiopod shells (Cooper & Grant 1972). Original biofabric is usually not preserved. Details of superficial shell structures are well preserved, but very fine details are missing. Internal structures, including spiral brachidia are preserved. Some shells show silicification only in the thickest parts (umbonal parts of brachiopods) leaving thinner shell parts unaltered. Silicified shells are fairly solid, depending on the original wall thickness.

I observed this type of silicification in various shells and skeletons but it is characteristic for those composed of calcite (brachiopods, rugose corals, bryozoans). High-magnesium calcite skeletons (crinoids) are imperfectly (chambered) and coarsely silicified. In more detailed view, there are differences in the quality of silicification among taxonomically unrelated brachiopods. Most of brachiopods are well preserved, while shells of *Lissatrypa* and strophomenoids are preserved only in the thickest parts of their shells. Only platycerid gastropods are silicified among gastropods. Bryozoans are well silicified. Corals include well preserved rugose corals having calcitic skeletons while tabulate corals are less perfectly silicified. Crinoids *Pisocrinus* are not wholly silicified or display coarse aggregations of silica (Fig. 2J, M, N). Size of skeletons ranges from 0.8 to ca. 50 mm. I observed this type of silicification in rhynchonelliform brachiopods, platycerid gastropods, bryozoans, rugose and tabulate corals and crinoids. It was found (Mergl 2003) in several thick limestone succession of bioclastic limestone of the Kotýs Limestone (Lochkov Formation, Lochkovian) between Bubovice and Vysoký Újezd. It has been known from bioclastic limestone of the Coral Chapel horizon of the Zlíchov Formation (early Emsian) in Prague territory (Praha - Hlubočepy) (Havlíček 1998).

⟵

Bubovice, Branžovy. O–Q Coarse spongiose and crystalline silicification: O – incomplete cranidium of a trilobite *Otarion*, interior; Kopanina Formation, Kosov Quarry. P – group of silicified shells of *Septatrypa*; Q – etched slab with silicified brachiopod shells; Požáry Formation, Kosov Quarry. Bar length is 5 mm.

(4) Coarse spongiose and crystalline silicification

Silicification of this type preserved only main features of shells. Fine details of shell and skeleton surface and many internal structures are completely missing. The shell wall is often only partly preserved (mostly in the thickest umbonal region), corroded and crystalline and/or microcrystalline silica forms massive mineral infilling inside the shell. Silicification sometimes copies the original fibrous biofabric. Delicate internal structures, such as brachidium are sometimes preserved being covered by mat of spongiose microcrystaline silica and three-dimensional irregular network of silica fibres and platelets. Internal structures are often completely destroyed by coarse silica infilling inside the shell.

This type of silicification affected only originally calcitic shells and skeletons. Their sizes usually range from 0.5 to c. 15 mm although I observed imperfect silicification also in coral skeleton having more that 100 mm. Larger skeletons or their parts have the same silicification as the small shells. Silicification affected mainly brachiopods, but there are differences among the groups. Strophomenoid brachiopods are left intact while some small orthids and smooth-shelled spire-bearers (smooth atrypids, spiriferids, athyrids) are silicified. Ostracods, trilobites and occasionally tabulate corals are also silicified. This type of silicification is widespread in the dark platy limestone of the upper part of the Kopanina Formation (Ludlow) and the Požáry Formation (Přídolí) in vicinity of Beroun and Praha – Řeporyje. Shells often form nests and lenses of densely packed shells bound by silicification.

DISCUSSION

Diverse types of silicification of fossils observed in the Barrandian indicate that this phenomenon can be very useful for studying fossils that cannot be obtained by other methods (e.g. washing and hammering). Silicified fossils display morphological details of remarkable quality. Perfect preservations of very small shells and skeletons may significantly enlarge our knowledge of early shell development having substantial impact on phylogeny estimates in particular invertebrate groups. Despite selectivity depending on shell mineralogy, better understanding of original benthic communities is possible by using silicified fossil in quantitative analyses.

Results of my research agree with observations of other authors (Laufeld & Jeppsson 1976). Silicification is always selective. It affects mostly originally calcitic skeletons in which shell size played a minor role, while silicification of aragonitic shells was finer and better in small-sized skeletons. Silicification of high-magnesium calcite was mostly but not always poor, incomplete, often producing coarse grained silica aggregates.

It is important to note, that the best silicification in the Silurian occurs in beds containing higher admixture of volcanic material. Therefore the best silicification is restricted to the Motol Formation, while younger formations have usually coarser silicification. The best preserved silicified fossils of micrometric size are preserved in the Motol Formation at Kosov quarry in a bed very rich in volcanic ash. In a residue with fossils substantial amount of unaltered volcanic ash and none other clastic material occurs. Volcanic material as a possible source of silica used in silicification of shells was suggested by Laufeld & Jeppsson (1976).

ACKNOWLEDGEMENTS

The author is greatly indebted for technical support to Jana Nebesářová, Jiří Vaněček and staff of SEM laboratory of Academy of Science of the Czech Republic, České Budějovice. This study was supported by a grant of the Grant Agency of the Czech Republic GAČR 205/07/0466: *Origin and evolution of the discinoid brachiopods in the Palaeozoic*.

REFERENCES

Cooper G.A. & Grant R.E., 1972: Permian brachiopods of West Texas. – Smithsonian Contributions to Palaeobiology 14: 1-231.

Havlíček V., 1998: Review of brachiopods in the Chapel Coral Horizon (Zlíchov Formation, lower Emsian, Lower Devonian, Prague Basin). – Věstník Českého Geologického Ústavu 73: 113-132.

Kříž J. 1992: Silurian field excursions: Prague Basin (Barrandian), Bohemia. – National Museum of Wales, Geological Series 13: 1-111. Cardiff.

Laufeld S. & Jeppsson L., 1976: Silicification and bentonites in the Silurian of Gotland. – Geologiska Föreninges i Stockholm Förhandlingar 98: 31-44.

Mergl M., 2003: Silicified brachiopods of the Kotýs Limestone (Lochkovian) in the Bubovice area (Barrandian, Bohemia). – Acta Musei Nationalis Pragae, Series B: Natural History 59: 99-150.