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BENTHIC CRINOIDS FROM THE TRIASSIC CASSIAN FORMATION OF THE DOLOMITES

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With 2 Plates

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The marls of the late Ladinian/early Carnian Cassian Formation have been painstakingly searched for more than 170 years for the beautifully preserved fossils that make this Fossillagerstätte one of the richest treasure troves of Mesozoic invertebrates. Its crinoid fauna is the most diverse Triassic fauna known from the western Tethys. However, unlike the obrutional conservation lagerstätten in the late Anisian/early Ladinian germanotype Muschelkalk, which has much less diverse crinoid faunas, articulated skeletons are extremely rare in the Cassian Formation. This is due to a relatively long transport from their original habitat to the area of deposition. Hence, the variety of crinoid sclerites forms a puzzle with many parts is still missing.

Most of the taxa established during the last 170 years are based on fragmentary material, mostly columnals, many of which are of limited diagnostic value and cannot be unequivocally attributed to a genus or even a species. For Count Münster (1834) cylindrical columnals similar to *Encrinus liliiformis* gave evidence for a Muschelkalk (Triassic) age of the Cassian Formation. Subsequently the Cassian crinoids were described within the classical monographs (Münster, 1841; Klipstein, 1845; Laube, 1864, 1865). New taxa were added by Bather (1909), Leonardi & Lovo (1950) and Zardini (1974), most of them as a result of Rinaldo Zardini´s collecting activity around Cortina d´ Ampezzo. Hagdorn (1988, 2004) started to subdivide the order Encrinida. However, a revision of the entire fauna is still a desideratum, especially in respect of its worldwide importance for the post-Palaeozoic crinoid radiation and mid Carnian extinction (Simms, 1990; Hagdorn, 2011).

This paper presents (1) a first step towards a revision of the Cassian benthic crinoids (the planktonic and benthic microcrinoids excluded), (2) evidence of their possible biostratigraphic value and (3) a first data set of their palaeogeographic distribution and relation to Eastern Tethyan faunas of this time interval.

At present, the following taxa can be distinguished:

Order Holocrinida	Family Tollmannicrinidae	
	Tollmannicrinus quinqueradiatus	rare columnals
Order Encrinida	Family Encrinidae	
	Encrinus sp. indet.	2 crowns, isolated sclerites
	Chelocrinus cassianus	a few crowns, many cups, isolated sclerites
	Cassianocrinus varians	a few crowns, many cups, isolated sclerites
	Zardinicrinus granulosus	1 crown, many cups, isolated sclerites
	Zardinicrinus tuberculatus	a few cups, isolated sclerites
	Family Traumatocrinidae	
	Traumatocrinus sp. indet.	a few columnals
	Family Ainigmacrinidae	
	Ainigmacrinus calyconodalis	a few cups, several calyconodals
Order Isocrinida	Family Isocrinidae	
	Tyrolecrinus tyrolensis	1 cup, 1 basal circle, columnals
	Balanocrinus subcrenatus	rare columnals
	Laevigatocrinus laevigatus	1 stem fragment, rare columnals
	"Isocrinus" propinquus	2 cups, columnals
	"Isocrinus" apetalus	rare columnals
	"Isocrinus" venustus	columnals
Order Millericrinida (?)	Family indet.	
	"Encrinus" cancellistriatus	columnals

As demonstrated by Bizzarini et al. (1989) and Broglio Loriga et al. (1999) for the planktonic microcrinoids, a faunistic succession can also be observed within the benthic crinoid faunas of the late Ladinian/Carnian sediments in the Dolomites. While Encrinida are rather common from the Ladinian Pachycardientuffe of the Seiser Alm and at the type locality of the Cassian Formation around Pralongia (Stuores Wiesen) up to the outcrops at Richthofenriff (Forcella Settsass), the outcrops along the Falzarego Road, near Lake Misurina, and on Seelandalm yielded no Encrinida and only a restricted number of Isocrinida species. This distribution reflects a major cut in the phylogeny of the post-Palaeozoic crinoids marked by the extinction of order Encrinida between *aonoides* and *austriacum* biozones (Simms, 1990; Hagdorn, 2011).

Thus, establishment of a Ladinian/Carnian crinoid biozonation for the Western Tethys on the base of abundant and easily determinable sclerites could serve as an additional, fairly high-resolving biochronological tool for such sediments that are poor in ammonoids or conodonts. For this purpose, the Dolomites are certainly the best place to start with. However, more bed-by-bed collecting will be necessary.

Moreover, this could be a second step towards a crinoid biochronology covering the entire Triassic that would continue the Anisian crinoid biochronology established by Hagdorn & Głuchowski (1993) and Hagdorn et al. (1997) downsection and upsection. Finally, analyses of biostratigraphically well dated crinoid faunas from other parts of the Tethys could serve for a reconstruction of a palaeobiogegraphical scenario.

Plates 1 and 2 aim to give photographic pictures of the type specimens that are housed in different European collections. As a good deal of this historical material was bought from cattle herds, specified locality data are not available. These specimens are mostly labelled "Cassianer Schichten, St. Cassian". Otherwise, locality data are given in the captions. Type and figured material of Cassian crinoids are deposited in the following collections

NHML	Natural History Museum London (originals of Klipstein 1843 – 1845)
BSP	Bayerische Staatssammlung für Paläontologie München (originals of Münster 1841)
GBA	Geologische Bundesanstalt Wien (originals of Laube 1865)
IGPT	Institut für Geologie und Paläontologie Tübingen (originals of Quenstedt 1874 – 1876)
MB	Museum für Naturkunde an der Humboldt Universität zu Berlin (originals Laube 1861)
MHI	Muschelkalkmuseum Ingelfingen (as yet unpublished material)
NHMW	Naturhistorisches Museum Wien (originals of Laube 1861)
SMNS	Staatliches Museum für Naturkunde Stuttgart (originals of Hagdorn 1983, 1988)

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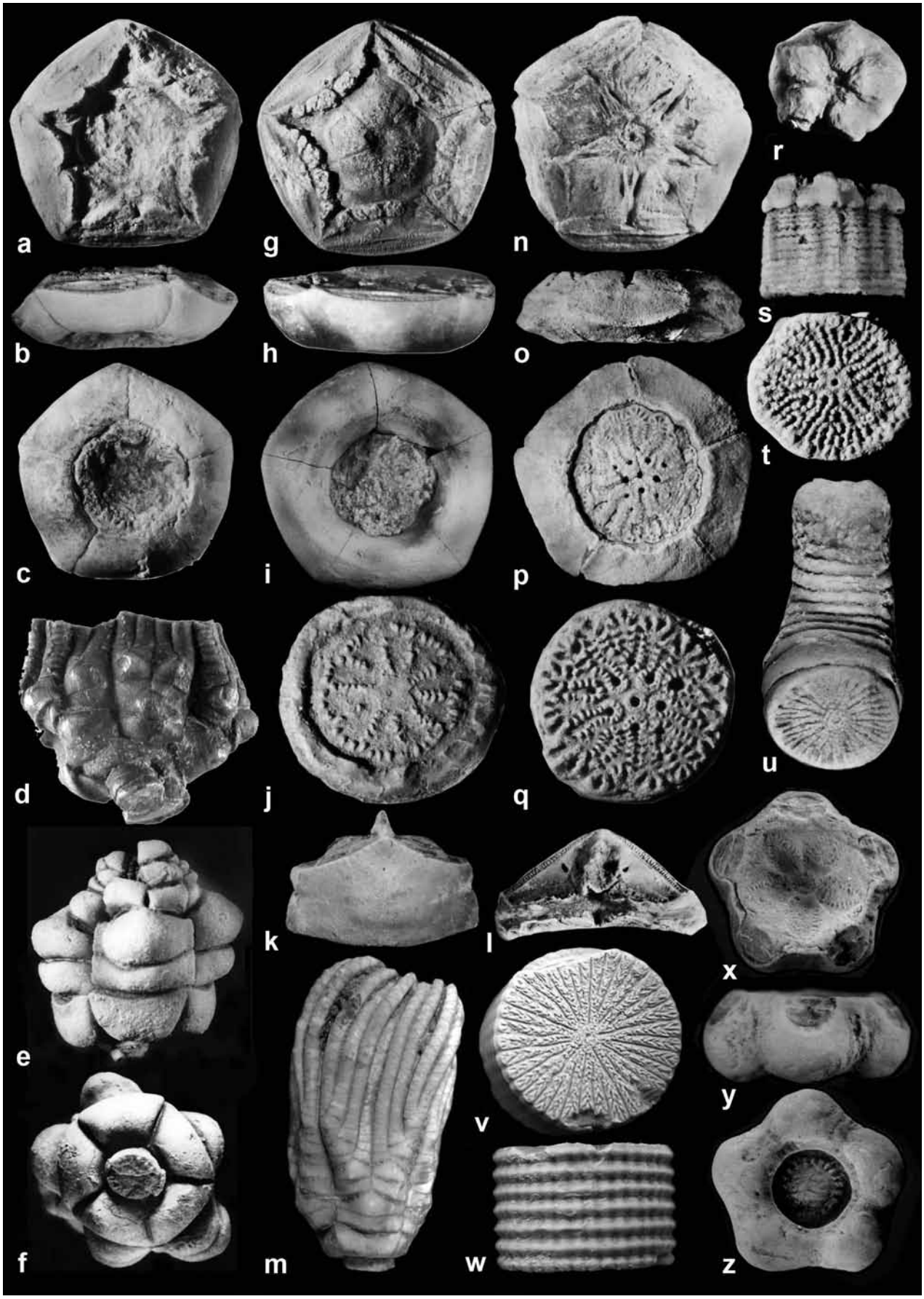

Plate 1: Encrinida.
a – d ***Chelocrinus cassianus*** **(Laube, 1864);**
a – c cup, orig. *Encrinus liliiformis* v. Münster 1841, pl. 5, fig. 6, BSPM 1877 X 1020; width 11 mm;
d crown, orig. *Encrinus cassianus*, holotype, Laube 1865, pl. 8a, fig. 1, MB uncatalogued; width 27 mm.
e – f ***Encrinus*** **sp. indet.;** crown, orig. *Encrinus cassianus*, Quenstedt 1874 – 1876, pl. 107, fig. 8, IGPT Qu. Ast. u. Encr. Tab. 107, fig. 8; width of cup 11 mm.
g – m *Cassianocrinus varians* **(v. Münster, 1841);**
g – i cup, orig. *Encrinus varians*, v. Münster 1841, lectotype, pl. 5, fig. 8, BSP 1877 X 1013; width 18 mm;
j proximal columnal, orig. v. Münster 1841, syntype, pl. 5, fig. 10 a, BSP 1877 X 1026; width 11,5 mm;
k – l primibrachials 1 + 2 axillary, orig. *Encrinus liliiformis* v. Münster 1841, pl. 5, fig. 7 c,d, BSP 1877 X 1025; width 14 mm;
m crown, orig. *Encrinus (Cassianocrinus) tetarakontadactylus* Laube, 1865, holotype, pl. 8b, fig. 1 – 3, NHMW 1865/IX/130; length 22,5 mm.
n – u ***Zardinicrinus granulosus*** **(Münster, 1834);**
n – p cup, orig. *Encrinus granulosus* (v. Münster, 1834), lectotype, v. Münster 1841, pl. 5, fig. 19, BSP 1877 X 1015; width 12,5 mm;
q pluricolumnal, syntype, v. Münster 1841, pl. 5, fig. 14, BSP 1877 X 1023; width 6 mm;
r – t proximal pluricolumnal with basal circle, syntype, v. Münster 1841, pl. 5, fig. 16, width 7 mm, BSP 1877 X 1010;
u distal pluricolumnal, syntype, v. Münster 1841, pl. 5, fig. 13 b, BSP 1877 X 1022; length 11 mm.
v – w ***Traumatocrinus*** **sp. indet.,** pluricolumnal, NHMW uncatalogued; width 8,7 mm.
x – z ***Ainigmacrinus calyconodalis*** **Hagdorn, 1988,** calyconodal, holotype, "Becken vom *subcrenatus*?" orig. v. Münster 1841, pl. 4, fig. 10, BSP AS VII 563; width 10,8 mm.

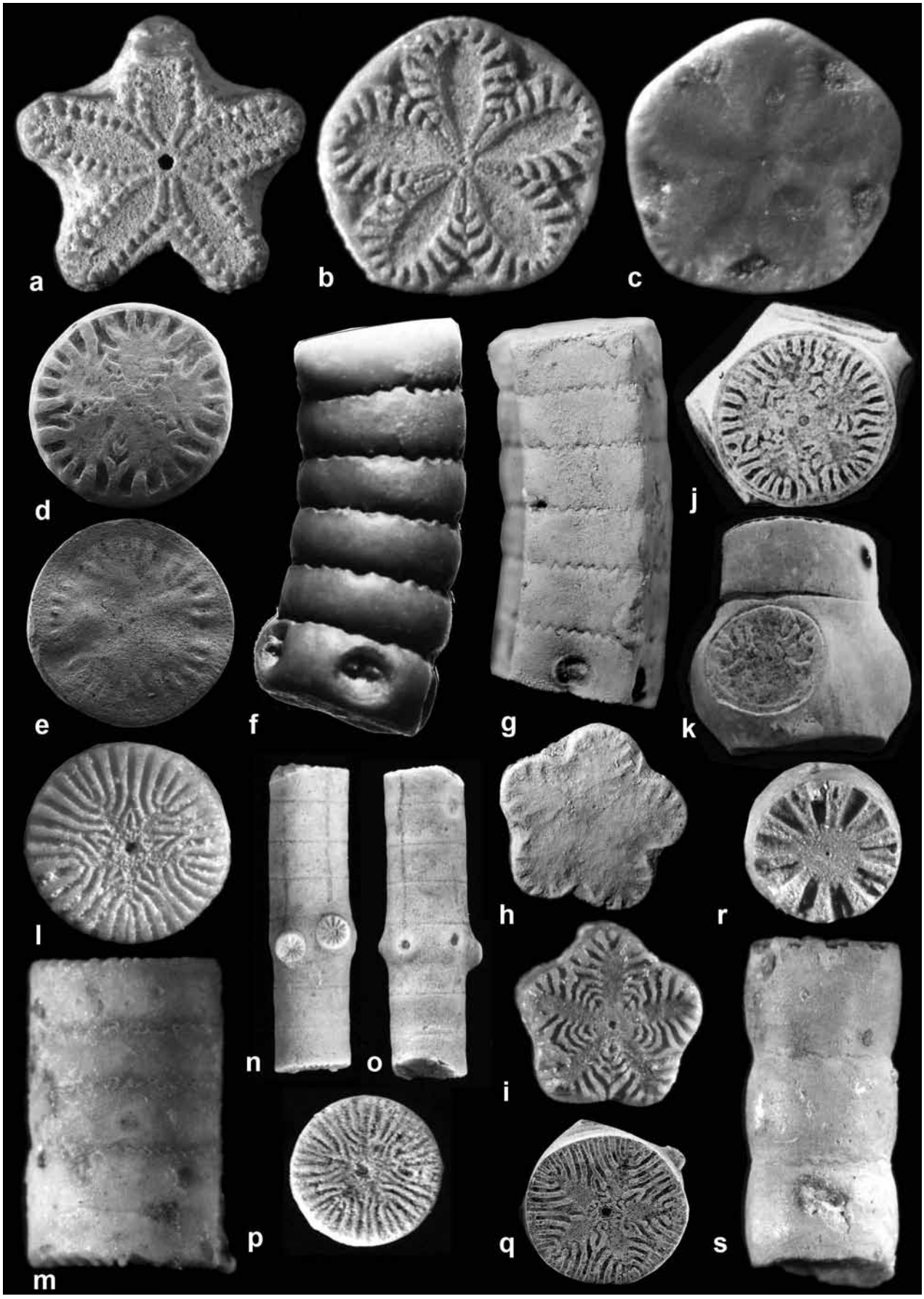

Plate 2: Isocrinida, Millericrinida.
a – c ***"Isocrinus" propinquus*** **v. Münster, 1834,** Stuores Wiesen; a proximal nodal, MHI 2063/1; width 5 mm; **b** internodal, MHI 2063/2; width 5,3 mm;
c hyponodal with synostosial articulation facet, MHI 2063/3; width 5,9 mm.
d – f ***Balanocrinus subcrenatus*** **(v. Münster, 1841);**
d pluricolumnal, internodal facet, Stuores Wiesen, Unterkarn, orig. Hagdorn 1983, fig. 1 a, SMNS 26337; width 4,5 mm;
e internodal, orig. Hagdorn 1983, fig. 1 b, Stuores Wiesen, SMNS 26338, width 4,5 mm;
f pluricolumnal, SMNS 26337; length 12 mm.
g – i ***Tyrolecrinus tyrolensis*** **(Laube, 1865);**
g – h pluricolumnal, synostosial lower nodal facet, holotype, orig. Laube 1865, GBA 1865/3/83; length 5 mm; **i** internodal, Seelandalm, MHI 2064/1; width 3,9 mm.
j – k ***Laevigatocrinus laevigatus*** **(Münster, 1841),** pluricolumnal with nodal, internodal facet, lectotype, orig. v. Münster 1841, pl. 4, fig. 7 b, g, BSP AS VII 912, width 5 mm;
l – m ***"Isocrinus" apetalus*** **Zardini 1976,** pluricolumnal, Forcella Giau; MHI 2065/1; width 3 mm;
n – q ***"Isocrinus" venustus*** **(Klipstein, 1845);**
n – p pluricolumnal, internodal facet enlarged, holotype, orig. Pentacrinus venustus Klipstein, 1845, NHML 75860; length 11 mm;
q pluricolumnal, internodal facet, Stuores Wiesen; MHI 2066; width 1,6 mm.
r – s ***"Encrinus" cancellistriatus*** **Bather, 1909,** pluricolumnal, Seelandalm; MHI 2067; width 3,5 mm.

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