

Verrucaria Schrader
(VERRUCARIALES: VERRUCARIACEAE)

After Various Authors

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Thallus crustose, superficial or immersed, continuous to rimose-areolate, usually whitish, greenish, brownish or black, sometimes powdery, often (in some marine or aquatic species) subgelatinous with vertical and palisade-like hyphae, and sometimes with black ridges (juga) or spots (punctae) present on surface; ecorticate, or sometimes with cortex; prothallus sometimes prominent.

Perithecia immersed in pits in the rock, or immersed in thallus or thalline warts, or erumpent to superficial, \pm globose; ostiole punctiform or radially cracked; involucrellum present in many species; true exciple colorless to brown or black, often dense and brittle; periphyses lining the ostiole; pseudoparaphyses-like filaments gelatinized early leaving mucilage and oil globules, absent in mature ascomata; without hymenial algae; asci ovoid to ovoid-clavate, clavate or oblong-clavate, with two distinct wall layers, discharge often obscure, Verrucaria-type, unitunicate, thick walled, I-, or the asci deliquescent leaving spore packets enclosed in mucilage; spores 8, oblong-ellipsoid to globose or somewhat fusiform, simple (sometimes with "pseudosepta"), hyaline (to brown according to Rogers), thin walled, smooth.

Pycnidia unknown in most species, when present immersed, Staurothele-type (with single central cavity lined by a layer of flask-shaped conidiogenous cells), fulcrum endobasidial; pycnospores acicular, straight or curved. No substances. Photobiont Myrmecia, Cocciobotrys, Pleurococcus, Heterococcus, Dilabifilum (Pseudopleurococcus), or other genera, unciellular, sometimes interspersed between hyphae in vertical rows. No substances. On calcareous or siliceous rocks, building materials, compacted sand and soil, including periodically maritime and freshwater species, very rarely on bark.

This genus is easily recognized on rocks or compacted sand by the discrete, scattered perithecia, absence of paraphyses when mature, and particularly the simple ascospores. Thelidium is distinguished by the presence of 1-septate ascospores, and Polyblastia by the muriform ascospores. Thrombium occurs on caly soils and has persistent paraphyses and and I+ blue ascus apex.

The genus is probably heterogeneous as currently circumscribed. In identification of the species it is important to pay particular attention to the texture of the thallus, immersion of the perithecia, whether any pits are formed in the rock, the nature of any involucrellum, and especially the size of the ascospores. Ascospore sizes can vary considerably within species, and mature spores for several different perithecia should be measured whenever practicable. The species concepts for the marine and freshwater species are now reasonably clear (although several species, such as V. maura, are extremely variable), but considerable work remains to be done on terrestrial ones, especially those on calcareous substrates.

Some caution must be used in interpreting species as marine, freshwater or terrestrial; for example, freshwater seepages running down rocks on the seashore may support freshwater and

not maritime species.

I. Marine and maritime species
(after Brodo & Santesson 1997, Santesson, unpubl., and others)

[Note: on shaded shores exposed to considerable freshwater seepage, freshwater or terrestrial species may also occur in the supralittoral zone]

I-A. Thallus without jugae (black ridges or dots).

- 1. Photobiont a brown alga (Petroderma maculiforme).** Thallus externally resembling a crustose alga, grayish buff when dry, blackish when wet. Perithecia immersed; spores 12-15 x 5-7 μ m. Intertidal zone, California. V. tavaresiae Moe
- 1. Photobiont a green alga.** 2
- 2. Perithecia entirely submerged within thallus, often only the ostiole visible (but forming distinct bumps raised above the thallus in V. schofieldii).**
..... 3
- 2. Perithecia partially buried in thallus or plainly elevated, rounded conical shaped, hemispherical or almost spherical elevated above the thallus.** 5
- 3. Spores 11.5-16 x 6-8 μ m; perithecia forming distinct bumps on thallus, 0.25-0.45 mm diam.** Queen Charlotte Islands, British Columbia. Frequent. V. schofieldii Brodo
- 3. Spores 8-10(-12) x 4-8 μ m; perithecia entirely immersed except for ostiole, 0.1-0.2 mm diam.** Bicoastal. 4
- 4. Thallus rimose-areolate, dull; involucrellum brown. Rare (at least on west coast).** Thallus divided into areoles by fissures. Perithecia 0.1-0.2 mm in diameter; spores 7-10 x 5-8 μ m. V. ceuthocarpa
- 4. Thallus smooth, or with a few fine cracks, often shiny; involucrellum carbonaceous. Rare in Queen Charlotte Islands, more common to the south.** Thallus generally without cracks or fissures, often shiny, olive-green, becoming dark green to black in the sun, distinctly green when wet, firm and subgelatinous, to 1 mm thick, often with a whitish prothallus. Spores 7-10(-15) x 4-8 μ m, relatively thick walled. Perithecia to 0.15 mm diam., immersed; exciple colorless; involucrellum a pale brown ring bordering the ostiole. In midlittoral zone, sunny or shaded, often with barnacles, macroalgae, and the crustose red alga Hildenbrandia, rarer on sheltered shore and intolerant of silt. Often infected by Stigmidium marinum.
Bicoastal. V. mucosa
- 5. Spores very large, mostly over 20 x 10 μ m.** 6
- 5. Spores medium to small, mostly under 20 x 10 μ m.** 11
- 6. Thallus dirty white to pale gray with streaks of dark gray to brown-gray or black.** Perithecia more or less hemispherical. Perithecia to 0.2 mm diam., semi-immersed; true exciple pale below; involucrellum black, clasping the upper half of the exciple. Thallus superficial, not subgelatinous, uneven, scabrid, cracked to irregularly areolate, composed of more or less separate areoles on a black prothallus. Spores 17-23 x 10-15 μ m. On shaded, damp or seepage siliceous rock in the supralittoral zone. East coast. V. internigrescens
- 6. Thallus \pm dark, not whitish or streaked.** 7

7. Thallus medium to dark brown, paler (in shade), regularly areolate, superficial, thin, areoles flat, sometimes widely separated, dull and somewhat scabrid; prothallus black and friable. Perithecia sessile, to 0.5 mm diam., often arising directly on the prothallus, or half-immersed in areoles; true exciple pale; involucrellum convex, extending beyond the true exciple. Spores 16-26 x 10-15 μ m, ellipsoid. On sunny, siliceous rocks in the supralittoral zone on seashores. Distribution? (not listed for West Coast by Brodo & Santesson; they say the descriptions in the literature are not consistent and have not seen reliable material). V. fusconigrescens

7. **Not as above.** West Coast. 8

8. Growing in central California. Spores 19.5-27 x 8.5-12.5 μ m, L:W = 2.2-2.3. Thallus black. Growing in the littoral or lower supralittoral fringe. Thallus thin or very thin, effuse, microscopically areolate and intricately fissured, appearing to naked eye as a daub of dead black paint, K-, C-. Perithecia numerous, at first low and covered by thallus, becoming more prominent and emergent, hemispherical, finally sessile and subglobose, apical portion then irregularly depressed and ostiole comparatively large; exciple entire, black; asci ovoid, clavate, and pyriform; hymenial gel I+ blue; spores ellipsoid. Rare, on rocks a few feet above the sea at Pt. Lobos (Monterey), associated with Pyrenocollema halodytes. Strongly resembling V. maura in general appearance, but differs in thinner thallus, much larger and differently shaped spores, and I+ blue (not red) reaction of hymenium. [I don't know iff this species has jugae; if does then it should not key out here]. V. melas Herre

8. Growing in the Queen Charlotte Islands, British Columbia. 9

9. Thallus thick, dull brownish, not gelatinous when wet; perithecia hemispherical to cylindrical, often covered with thalline tissue; spores 24-32 x 12-15 μ m, L:W = ca. 2.0-2.1.

Thallus clearly visible, thick. Thallus edge definite, not lobate. Thallus mostly continuous, rugose, rimose, or areolate, without jugae, light brown to pale orange, light yellowish brown or pale orange-yellow, dull, not gelatinous when wet, without a black, basal medullary layer. Photobiont chlorococcoid. Perithecia occurring singly, sessile and very prominent, covered with a thin layer of thallus or naked and black, epruinose, 0.3-0.55 mm diam., hemispherical to almost cylindrical. Ostioles level with perithecial surface, or slightly depressed. Involucrellum carbonaceous, very thick, 60-80 μ m, covering over half of centrum, not covering base. Excipulum not distinguishable from involucrellum, or pale at base and distinct. Centrum 170 μ m high, 150 μ m wide, hyaline, I-. Periphyses conspicuous, stout, stiff. Spores 24-32 x 12-15.5 μ m, L:W = c. 2.1 Pycnidia not observed. Growing directly on non-calcareous, shoreline rocks, middle hygrohaline zone, alongside V. maura. Rare. Queen Charlotte Islands. V. sp. 1 (Brodo & Santesson 1997)

9. Thallus membranous to endolithic, gelatinous or not gelatinous when wet; perithecia black, superficial; spores 19-35 x 9.5-17 μ m, L:W = 1.7-1.9. 10

10. Growing on HCl+ (calcareous) rock; thallus endolithic; perithecia 0.3-0.4 μ m diam. Rare. Queen Charlotte Islands. V. sp. 5 (Brodo & Santesson 1997)

10. Growing on HCl- (siliceous) rock; thallus thin to membranous; perithecia 0.4-0.6(-0.8) μ m diam. Thallus clearly visible, membranous with an indefinite edge, mostly continuous, \pm smooth, or rimose in thickest spots, without jugae, light to medium yellowish brown to grayish yellowish brown, dull, not gelatinous when wet, without a black, basal, medullary layer. Photobiont chlorococcoid. Perithecia occurring singly, superficial, black or almost, epruinose, 0.35-0.6(-0.8) mm diam., hemispherical or

- conical. Ostioles level with perithecial surface. Involucrellum carbonaceous, covering over half of centrum, not covering base. Excipulum distinct from involucrellum at least at base, darkly pigmented but not carbonaceous, pale, or hyaline. Centrum 170 μ m high, 200 μ m wide, hyaline. Periphyses not observed. Spores (18.5-)21-30(-35.5) \times (9.5-)12-17 μ m; L:W = 1.7-1.9. Pycnidia not observed. Growing directly on rock, upper hygrohaline to lower aerohaline zone. Infrequent. Queen Charlotte Islands. V. sp. 2 (Brodo & Santesson 1997)
- 11. Spores 12-14 \times 2-3 μ m**, narrowly ellipsoid. Thallus dark brown to blackish, very thin, subgelatinous, effuse. Perithecia to 0.15 mm diam., sessile, hemispherical, often flattened; exciple pale at base; involucrellum rough, extending beyond the true exciple. On sheltered siliceous or ultramafic rock in littoral zone. Apparently rare, Washington. V. sandstedei
- 11. Spores over 3 μ m wide, and either longer or shorter than the above.** 12
- 12. Spore L:W = 2.4-3.1; spores (14-)16-21(-25) \times (4.5-)6.5-9(-10) μ m; thallus brown, membranous.** Perithecia 0.2-0.4 mm across; thallus smooth, extremely thin to moderately thick, continuous, membranous, black to dark brown or dark greenish gray, smooth to rough, becoming chinky, sometimes appearing minutely granulose, forming a kind of fimbriate network resembling a prothallus; composed of dark brown paraplectenchyma with cells ca. 4.5-6.5 μ m diam. Perithecia scattered or \pm clustered, immersed to partly superficial; wall dimidiate and centrally open below; superficial portion subhemispherical or subconical, dull black; ostiole minute, often scarcely visible. Spores oblong-ellipsoid, irregularly arranged. On a littoral quartz pebble. Long Island, New York; Queen Charlotte Islands. V. silicicola Fink
- 12. Spore L:W mostly \leq 2.0.** 13
- 13. Thallus white to pale gray, always with a mauve tinge**, superficial, often poorly developed, discontinuous, soft and crumbling, not subgelatinous, scabrid; prothallus indistinct. Perithecia to 0.8 mm diam., black, prominent, sometimes 2 or 3 contiguous; exciple black, even at the base; involucrellum closely clasping the exciple. Spores 12-15 \times 7-10 μ m, ellipsoid, the ends abruptly truncate. On vertical shaded faces, or in dry crevices on soft, siliceous rocks, especially schists, most frequently in the mesic to xeric-supralittoral zones. Alaska. V. prominula
- 13. Thallus brown, olive, or black.** 14
- 14. Spores 11.5-14.5(-16) \times 6.5-7.5(-8) μ m, L:W = 1.7-2.1.** Queen Charlotte Islands, British Columbia. V. schofieldii Brodo
- 14. Spores 8-11(-12) \times 4.5-6.5 μ m.** 15
- 15. Involucrellum lacking. Perithecia often appearing globulose and set on the thallus.** Thallus brownish black, continuous or chinky or becoming chinky-areolate, smooth, without jugae, thin. No distinct prothallus. Exciple reddish brown or dark brown. Spores 5-12 \times 4-7 μ m. Eurasian Arctic; not yet known from N. America. See Thomson 1997 for full description. [V. halophiloides]
- 15. Involucrellum present. Perithecia hemispherical.** 16
- 16. Thallus brown, membranous; excipulum pale at base.** Rare. Spores (6-)7-9(-10) \times (3-)4-5(-7) μ m; perithecia 0.1-0.2 mm across. Thallus very thin, filmy, pale olive green or pale to sordid dark brown in the sun, translucent when wet, often bordered by black prothallus. Perithecia to 0.25 mm diam., sessile, hemispherical; exciple brownish, pale at base; involucrellum extending widely, with clear gap between it and the true exciple. Usually amongst V. mucosa, V. striatula, and the red, crustose alga Hildenbrandia,

forming patches 1-2 cm diam. in crevices and shade in the mid-littoral; occasionally infected with the lichenicolous fungus Stigmidium marinum, with colorless 1-septate ascospores. Bicoastal. Washington State; Queen Charlotte Islands.V. halizoa Leighton (V. halophila Branth & Rostr., 1869)

16. Thallus black to dark olive, rarely brown; excipulum carbonaceous throughout.
Bicoastal. V. erichsenii Zschacke (rare form almost lacking jugae)

I-B. Thallus with scattered to abundant jugae.

1. Thallus very thick, usually circular, often distinctly lobed at edge, with elongated, branched, radiating jugae, especially at margin; spores subspherical, 7-10 x 6.3-8 um; perithecia entirely immersed, only a pale ostiole visible, not forming a bump on the thallus.

Perithecia not producing distinct bumps, 0.1-0.25 mm diam. Spores 7-10 x 6.5-7.5(-8) um, subglobose. Usually epiphytic on V. maura, upper to lower hygrohaline zone. Common, Alaska to Washington state (I included this species under V. maura in my 1988a paper, but had a feeling it was probably distinct). V. epimaura Brodo

1. Thallus thin or thick, usually indefinite in shape, without lobes; jugae not radiating or branched (but anastomosing in V. amphibia); spores ellipsoid. 2

2. Thallus usually thick, rimose-areolate, with abundant, mostly punctiform jugae (best seen near the periphery or on thalli in shade), often creating a rough, almost scabrid texture; basal medullary layer black. Perithecia buried in thallus, but producing distinct bumps when mature. Thallus blackish (brown near edge, sometimes greenish), usually matt, with many small, generally thick (to 1 mm) and fissured, the areoles flat with angular edges (like cracked mud), brown and only weakly rimose in shade. Perithecia semi-immersed; exciple pale to dark brown at base; involucrellum extended and wide-spreading. Spores 12-15 x 7-10 um, ovate. Forming a black band in the supralittoral fringe, sometimes (on wind-exposed cliffs or on moist, shaded shores) extending higher. Bicoastal. Very common. V. maura

2. Thallus thin or thick, without a black basal medullary layer. 3

3. Growing in central California. Spores 19.5-27 x 8.5-12.5 um, L:W = 2.2-2.3. Thallus black. Growing in the littoral or lower supralittoral fringe. Thallus thin or very thin, effuse, microscopically areolate and intricately fissured, appearing to naked eye as a daub of dead black paint, K-, C-. Perithecia numerous, at first low and covered by thallus, becoming more prominent and emergent, hemispherical, finally sessile and subglobose, apical portion then irregularly depressed and ostiole comparatively large; exciple entire, black; asci ovoid, clavate, and pyriform; hymenial gel I+ blue; spores ellipsoid. Rare, on rocks a few feet above the sea at Pt. Lobos (Monterey), associated with Pyrenocollema halodytes. Strongly resembling V. maura in general appearance, but differs in thinner thallus, much larger and differently shaped spores, and I+ blue (not red) reaction of hymenium. [I don't know iff this species has jugae; if not then it should not key out here]. V. melas Herre

3. Growing in northern or eastern areas. 4

4. Thallus with scattered, punctiform jugae. 5

4. Thallus with abundant, prominent jugae of various shapes. Rare, at least on West Coast. 8

5. Spores 11.5-16 x 6.5-8 um; perithecia entirely immersed or partially buried in thallus.

Rather common, Queen Charlotte Islands. V. schofieldii Brodo

5. Spores 7-12 x 4-7 um; perithecia superficial. 6

6. Thallus thin or thick, areolate, with elongate, black jugae outlining the areoles, as well as punctiform jugae on the areole surface. Involucrellum small, black, plate-like, not enveloping the exciple. Perithecia immersed, globose; exciple pale; Thallus to 1 mm thick, dull blackish green, scabrid, finely and regularly areolate; areoles with small thickened black edges and with black ridges forming a network on the surface; medulla and prothallus white. Perithecia 0.1-0.2 mm diam. Spores 7-10(-16) x (4-)5-6(-8) um.

Forming patches 1-2 cm diam. amongst other maritime lichens, on sheltered shores.

Bicoastal. Washington State; Queen Charlotte Islands.V. degelii

6. Thallus thin, membranous, rarely thickish, not areolate; jugae mostly punctiform.

[Need to see how Taylor distinguished the next two species from each other].

7

7. Spores kidney- or "D"-shaped. Involucrellum completely enclosing exciple. Exciple colorless or pale brown, with age becoming brown or black at base. Thallus dark brown, very thin, developing tiny black, non-glossy, friable dots or papillae (especially in the sun), which can coalesce, becoming scabrid and dirty brown-black, not distinctly ridged, areolate or otherwise patterned; prothallus indistinct. Perithecia sessile, elevated, to 0.2 mm diam. Thallus subgelatinous, translucent when wet, Perithecia regular, convex, hemispherical; exciple colorless or pale brown, with age becoming brown or black at base; involucrellum thin, completely enclosing the exciple. Spores 7-10 x 4-7 μ m, kidney- or "D"-shaped, relatively thick-walled. On intertidal shingle on mudflats, estuaries, etc. or in the littoral zone on sheltered rocky shores, in shaded and sheltered microhabitats, east coast.V. ditmarsica

7. Spores ellipsoid or broadly ellipsoid. Involucrellum close around the ostiole, spreading laterally. Exciple brown-black. Spores 8.5-10(-12.5) x 4.5-6.0(-7) μ m. Thallus generally with long, inconspicuous ridges and/or small points covering surface. Thallus thin, continuous, rough-dotted with irregular and often branched ridges, appearing dark-dotted when wet, blackish brown becoming translucent when wet, dull. Perithecia projecting hemispherically from thallus, black; exciple spherical, brown-black; involucrellum black, close around the narrow ostiole, spreading laterally; gelatin I- or pale reddish; spores ellipsoid or broadly ellipsoid. On seacoast rocks and pebbles in the splash zone, just below V. maura. Bicoastal. Material on serpentine rock from Washington state often has two perithecia per wart. V. erichsenii

8. Perithecia 0.4-0.6 mm diam.; spores 12-16 x 6-8 μ m; thallus rimose-areolate, with black ridges outlining the areoles. Spores 12-15 x 7-10 μ m, ellipsoid. Thallus very variable, thin, subgelatinous, bright grass-green (or brown, at least in herbarium), translucent when wet, becoming obscured by fine, black, glossy ridges 20-50 μ m wide, which coalesce to resemble fingerprints, the ridges developing extensively in strong light, the entire thallus then glossy black with fine ridges radiating at the edge; areoles with "canals" just inside the margins, giving the appearance of a marginal ridge; "canals" often lighter color than ridges and raised areas; center of areoles often raised; prothallus, when present, pale brown. Perithecia sessile, 0.4-0.5 mm diam, weakly fluted, \pm short-cylindrical, steep-sided, with a flat or concave top and crenellate rim; involucrellum thick and extending, usually coalescing with the thalline ridges. On rocks in the littoral zone, below V. maura, east coast, and Queen Charlotte Islands, British Columbia. Some material of V. maura from Washington State somewhat resembles this species, but has a black medulla and more rounded, rather than steep-sided, perithecia.V. amphibia

8. Perithecia 0.1-0.3 mm diam.; spores 7-12 x 4-6.5 μ m; thallus thin or thick. 9

9. Thallus areolate, with black jugae at edges of areoles, forming ridges and points elsewhere on the areole surface. V. degelii

9. Thallus thin (thick according to some authors), continuous, not areolate; broad, irregular black jugae abundantly produced over the thallus surface. Thallus greenish black or green, with long black, glossy, branched and swollen ridges 100-200 μ m wide (sometimes obscuring the thallus, sometimes shortened to somewhat wartlike, or poorly developed to absent in the shade),

otherwise subgelatinous, translucent when wet, sometimes reduced (by grazing or abrasion) to small patches around the juga. Perithecia to 0.3 mm diam., sessile, frequently irregular, frequently impressed on top, becoming excavate to one side when old, the ostioles large; exciple usually pale at base; involucrellum clasping the exciple, then extending a little at the base.

Spores 7-10 x 4-5(-7) μ m. In the mid-littoral zone, on siliceous or calcareous rocks, between V. amphibia (or V. maura) and V. mucosa, often amongst the crustose red alga Hildenbrandia.

Bicoastal.V. striatula

II. Freshwater Species (After Swinscow, and others)

1. Thallus with numerous small carbonaceous structures (juga) appearing as black dots or bumps (ca. 30 µm diam.) on a green or gray-green background (brown in herbarium), to 100 µm thick, subgelatinous; prothallus, when present, white or black. Perithecia immersed, 0.1-0.2 mm diam.; involucrellum not distinctly formed; excipulum continuous, black above but brown to colorless below. Spores broadly ellipsoid, (7-)10-12(-15) x (5-)6-8(-10) µm. Hymenial gelatin I- (pale red). On semi-inundated hard siliceous rocks in lakes and streams. [An unidentified species with juga but with a blackish thallus and differing otherwise also occurs in N. America].V. rheitophila

1. Thallus without juga.2

2. Spores subglobose (to broadly ellipsoid), 8-12(-15) x (6-)8-10 µm (L:W = 1-1.2).

Thallus thin to moderately thick, brown to gray-black, matt; areoles smooth, small, convex to verrucose, discrete or ± confluent, forming areolate-verrucose crust (with minute argillaceous granules between the areoles), or reduced to a few small verrucae around the perithecia. Algal layer 125 µm, algae densely crowded, not distinctly seriate. Perithecia frequent, 1/2-1/3 immersed in thalline areoles; upper part prominent, at tips nitid, around ostiole not or slightly impressed; perithecia globose, 0.25-0.4 mm diam.; excipulum entire, black-fuliginous, rather fragile, upper 1/2-2/3 covered by a thick carbonaceous involucrellum; involucrellum and excipulum not separated, but a clearing by chloral hydrate will often loosen the involucrellum; asci narrow, 50-55 x 12-14 µm, often subcylindrical, spores uniseriate. Hymenial gel I+ red. On chalk rocks, occasionally on slates, probably frequently irrigated by fresh water. Belongs to the V. aethiobola group according to Lynge. (V. arctica)

2. Spores broadly to narrowly ellipsoid; L:W ≥ 1.3).3

3. Spores 10-12 x 4-6 µm. Perithecia 0.1-0.2 mm, ± immersed. Thallus pale brown, very thin. Washington.V. sp.

3. Spores over 14 µm long and 6 µm wide.4

4. Perithecia ± sessile, covered by thallus only at base. 5

4. Perithecia ± immersed, though often in raised thalline warts.6

5. Involucrellum apical. Thallus white-gray. Spores 20-30 x 9-17 µm. Perithecia 0.1-0.3 mm diameter. Thallus continuous to rimose, non-gelatinous. On siliceous rock.V. submersella

5. Involucrellum extending down to middle or lower part of perithecium, not spreading (broadened laterally according to Thomson), thick, dark brown to black, exposed; exciple continuous (to dimidiate according to Thomson), colorless or dark brown; ostiole (according to Thomson) thin to broadening. Thallus to 0.2 mm thick, irregularly cracked to almost areolate, not gelatinous (gelatinous according to Thomson), ± dark, brownish red to ± brown or occasionally grayish; prothallus absent or poorly developed. Spores (12-)16-25(-32) x (5-)8-12(-15) µm, elongate-ellipsoid. Perithecia 0.2-0.4 mm diam., semi- to almost entirely immersed, often several in each areole, or sometimes ± projecting, hemispherical with the base broadened. Hymenial gelatin I+ violet. On semi-inundated, hard, usually siliceous rocks, often associated with Ionaspis lacustris, arctic to temperate.V. aethiobola

6. Spores often over 30 µm long. Spores 24-38 x 10-20 µm. Perithecia immersed in hemispherical warts. Involucrellum reaching down to lower half of the perithecia,

distinctly spreading at base. Thallus thin, smooth., continuous to here and there rimose. 7

6. Spores mostly under 30 um long. 8

7. Black basal layer often present, or at least a blackish layer of the medulla. Perithecial warts 0.4-0.6(-0.7) mm wide, usually only the tip exposed. Algae to 10 um wide. Algal layer mostly not entirely paraplectenchymatous. Exciple 0.2-0.4 mm diam. Thallus dark brown, black-grown or dark gray, often green spotted. Spores (24-)30-37(-40) x 11-17(-20) um, broad, ovate-ellipsoid, sometimes 1-pseudoseptate. Perithecia scattered, (0.3-)0.35-0.5(-0.7) mm, immersed (except around ostiole) in raised hemispherical warts; excipulum dark brown to black in places; involucrellum sometimes spreading at base; exciple dark brown above but often colorless below. Thallus greenish, dark gray or black-brown, sometimes greenish tinged, to ca. 50 um thick, \pm continuous to slightly rimose-areolate when dry, sometimes breaking up into irregular patches, subgelatinous, very smooth; black prothallus occasionally present. Hymenial gelatin I+ violet. On permanently submerged to semi-inundated, hard siliceous rocks by lakes and rivers, \pm arctic-alpine. V. margacea

7. Black basal layer lacking. Perithecial warts (0.2-)0.4-0.5 mm wide; apex later almost bare. Algae mostly to 1- um diam., but some to 20 x 10 um. Algal layer entirely paraplectenchymatous. Exciple to 0.3 mm. Thallus olive green to dark brown or almost blackish. Queen Charlotte Islands, British Columbia. Spores 33-42 x 12-14 um. Thallus thin, membranous. V. applanata

8. Thallus pale, whitish, grayish, brownish or pinkish. 9

8. Thallus dark, greenish or blackish. 10

9. Excipulum usually \pm colorless throughout. Thallus pale brownish white, pale grayish white, or pinkish (then K \pm reddish purple). Thallus to 0.15 mm thick, smooth or irregularly cracked, not gelatinous; prothallus where visible black. Perithecia (0.2-)0.25-0.3(-0.4) mm diam., immersed, the thallus only slightly raised in the vicinity of the ostiole; involucrellum not spreading, thick dark brown to black; true exciple continuous. Spores (17-)20-25(-27) x (6-)7-9(-11) um, elongate-ellipsoid to broadly fusiform. On submerged or \pm continuously inundated, hard, siliceous rocks, exceptionally on limestones, in lakes and rivers. Queen Charlotte Islands. V. praetermissa (Trevisan) Anzi

9. Excipulum brown-black. Thallus ashy gray, K-. Thallus continuous, only partly areolate, superficial, to 0.3 mm thick; areoles plane. Hymenium I-. Perithecia immersed in the areoles, with black tips slightly projecting, the excipulum thickened around the ostiole. Involucrellum absent. Spores elongate-ellipsoid, 18-28 x 6-10 um. On acid rocks in wet situations, Alaska. Not mentioned by Thomson 1997. V. divergescens

10. Involucrellum well developed, spreading into thallus at base. Perithecia 0.3-0.5(-0.65) mm diam. Spores 18-25(-34) x (7-)8-10 um. Thallus to 50 um thick, brownish-greenish, green to blackish green, subgelatinous, smooth, generally uncracked; prothallus dark brown to black, occasionally apparent at margin. Perithecia immersed in low hemispherical warts; exciple colorless or pale brown, continuous. On siliceous rocks in or by rivers and streams, which are regularly or permanently submerged, more rarely on flushed or damp rocks. V. hydrela

10. Involucrellum poorly developed, scarcely extending laterally beyond the true exciple from which it is scarcely distinguishable. Perithecia 0.2-0.3 mm diam. Spores 11-22(-28) x 6-8(-10) um. Thallus thicker, superficial, subgelatinous, dark greenish black, smooth but generally with irregular cracks; prothallus indistinct, creamy

or black. Perithecia remaining immersed, only the ostioles visible as small black dots from above, mainly 0.2-0.3 mm diam.; involucrellum dark brown, true exciple dark brown above and colorless below. Spores narrowly ellipsoid, rounded at the apices. On inundated or submerged siliceous rocks in streams and rivers and on lake shores. Queen Charlotte Islands; etc. V. funckii

III. On Dry Rock (after various authors)

III-A-1. On Calcareous (HCl+) Substrates

Perithecia \pm entirely immersed.

Thallus endolithic or inconspicuous.

1. Thallus with a rose, pink, or purplish color. Thallus thin, epilithic. Perithecia entirely immersed with only the carbonaceous apical portion of the excipulum showing, the rest of the excipulum being hyaline; involucrellum absent. Spores 18-28 x 11-15 μ m. On calcareous rock, southeastern U.S. (V. marmorea)

1. Thallus without a reddish tint of any kind. 2

2. Visible part of perithecia distinctly reddish. Arizona, Texas.
V. sp.

2. Visible part of perithecia black. 3

3. Involucrellum not furrowed or cracked, nor spreading horizontally. Exciple brown-black to black. Perithecia sunken into pits eaten into the rock, almost entirely immersed. 0.15-0.4 mm diam., simple, black; apex 0.15-0.3 mm diam., convex. Thallus mostly endolithic, white to pale gray, occasionally darker, smooth, continuous, with fine cracks radiating from the perithecia, delicately pitted, occasionally with a dark brown prothallus. Spores (13-)18-24(-28) x (7-)9-11(-14) μ m. On hard limestones. Arizona, California, Texas (and probably elsewhere). V. calciseda

3. Involucrellum radially furrowed and cracked, \pm supassing the thallus surface and spreading horizontally Exciple brown or partially pale. Involucrellum c. 0.4 mm wide, slightly swollen in center; perithecia 0.3-0.35 mm wide, completely immersed, only the involucrellum visible. Spores 18-20(-35) x 10-13 μ m, very rarely mixed with weakly septate ones. Thallus thin, uniform, endolithic or weakly epilithic, sordid whitish to white, with spherical "macrosphaeroids". On limestone or dolomite. Verrucaria (Bagliettoa) sphinctrina

III-A-2. On Calcareous (HCl+) Substrates

Perithecia \pm entirely immersed.

Thallus epilithic, \pm conspicuous, pale.

1. Thallus with a rose, pink, or purplish color. Involucrellum absent. Thallus thin, epilithic. Perithecia entirely immersed with only the carbonaceous apical portion of the excipulum showing, the rest of the excipulum being hyaline. Spores 18-28 x 11-15 μ m. On calcareous rock, southeastern U.S. V. marmorea

1. Thallus without a reddish tint of any kind. Involucrellum present. 2

2. Involucrellum 0.1-0.25 mm diam. Thallus deeply areolate. 3

2. Involucrellum 0.3-0.5(-0.8) mm diam. Thallus rimose-areolate. 4

3. Thallus 0.2-1.0(-1.5) mm thick; areoles with a black edge. Thallus distinctly superficial. Perithecia compound, entirely immersed but not sunken into pits. Thallus 0.2-1.0(-1.5) mm thick, pale to dark gray, gray-brown, olive-brown or dark brown, deeply areolate, delimited by a brown-black prothallus that is also visible beneath the 0.1-0.4 mm wide areoles (thin-section) and usually forms a black rim to these. Perithecia compound, numerous, entirely immersed; apex flat; involucrellum 0.1-0.25 mm diam., apical, dimidiate or extending to and merging with prothallus, black; centrum 0.1-0.2 mm diam., globose; true exciple colorless to black. Spores 10-18(-23) x 5-8 μ m. On calcareous rocks, especially limestone, also on walls and mortar. Mid-west and western U.S. (subsp. canella (Nyl.) A. L. Sm. [V. canella Nyl.] is distinguished by the more elongated spores 20-30(-32) x (5-)7-8(-10) μ m, and may be identical to V. aspicilioidea. V. glaucina auct. brit., non Ach.

3. Thallus 0.1-0.3 mm thick; areoles without a black edge, blue-gray (rarely gray, gray-green or gray-brown), edges not blackened, rimose to finely areolate, occasionally with dark brown prothallus. Perithecia compound; involucrellum 0.15-0.3 mm diam., dimidiate, black; apex flat to slightly convex; ostiole often depressed; centrum 0.15-0.25 mm diam., globose; true exciple colorless to black. On hard, rather shaded limestones. California. (V. caerulea)

4. Thallus very thick (0.5-2 mm), white to greenish gray or reddish gray; areoles coarse (0.5-2 mm), of "skvamet" aspect, often \pm lobed; medulla white to brown or black. Perithecia 0.4-0.5 mm diam., with involucrellum present only around the ostiole and excipulum \pm bottle-shaped, immersed or almost immersed, with black exciple and involucrellum. Spores 21-40 x 13-22 μ m. Arizona. V. obductilis

4. Thallus thin (< 0.5 mm), brownish (pale or somewhat greenish), sometimes somewhat becoming green on account of "alvado", without black basal layer, rimose-areolate. Perithecia 0.2-0.4 mm, with involucrellum well developed, completely fused with the exciple, covering the upper 1/4, which projects above the rock. Spores 18-35 x 10-17 μ m. On calcareous rocks, walls and mortar. Colorado, Indiana. (V. viridula)

III-A-3. On Calcareous (HCl+) Substrates

Perithecia \pm entirely immersed.

Thallus epilithic, \pm conspicuous, dark.

1. Thallus with radiating marginal areoles. Thallus dark gray to reddish brown; border areoles to 2 mm long, 0.2 mm wide, partly in lines, areoles in thallus center more angular when sterile to becoming almost spherical when bearing perithecia; a darkened 20-cell-thick superficial layer is over the cortex which has groups of algae distributed within. Perithecia single in nearly spherical areolae to center of thallus, completely immersed, only the mouth showing as a tiny dark dot which partly shows a whitened central dot where periphyses are present at the opening; excipulum subcompound, pale below, dark around the mouth; lower part of excipulum hypaline, contents I+ red; spores 8, ellipsoid-elongate, 22-28 x 8-10 μ m. On calcareous shale, British Columbia. V. lobata

1. Thallus without radiating marginal areoles. 2

2. Perithecia 0.2-0.4 mm diam., the upper 1/4 projecting. Thallus rimose-areolate.

Thallus thin (< 0.5 mm), brownish (pale or somewhat greenish), sometimes somewhat becoming green on account of "alvado", without black basal layer, rimose-areolate.

Perithecia 0.2-0.4 mm, with involucrellum well developed, completely fused with the exciple, covering the upper 1/4, which projects above the rock. Spores 18-35 x 10-17 μ m. On calcareous rocks, walls and mortar. Colorado, Indiana. (V. viridula)

2. Perithecia to 0.2(-0.25) mm diam., entirely immersed to semi-immersed. Thallus deeply areolate. Thallus 0.2-1.0(-1.5) mm thick; areoles with a black edge. Thallus distinctly superficial. Perithecia compound, entirely immersed but not sunken into pits. Thallus 0.2-1.0(-1.5) mm thick, pale to dark gray, gray-brown, olive-brown or dark brown, deeply areolate, delimited by a brown-black prothallus that is also visible beneath the 0.1-0.4 mm wide areoles (thin-section) and usually forms a black rim to these. Perithecia compound, numerous, entirely immersed; apex flat; involucrellum 0.1-0.25 mm diam., apical, dimidiate or extending to and merging with prothallus, black; centrum 0.1-0.2 mm diam., globose; true exciple colorless to black. Spores 10-18(-23) x 5-8 μ m. On calcareous rocks, especially limestone, also on walls and mortar. Mid-west and western U.S. (subsp. canella (Nyl.) A. L. Sm. [V. canella Nyl.] is distinguished by the more elongated spores 20-30(-32) x (5-)7-8(-10) μ m, and may be identical to V. aspicilioidea. V. glaucina auct. brit., non Ach.

III-A-3. On Calcareous (HCl+) Substrates
Perithecia emergent or sessile.
Thallus endolithic or inconspicuous.

1. Spores averaging over 25- um long. 2
1. Spores averaging less than 25 um long. 3
 2. **Perithecia 1/2-2/3 immersed.** Spores 24-40 x 14-24 um. Thallus immersed and indistinct to superficial and diffuse, rimose or areolate, pale gray-green or gray-brown, sometimes patchily reddish brown, with or without a dark brown, delimiting prothalline line. Perithecia compound; apex convex, flat or excavate; involucrellum (0.4-)0.6(-1.0) mm diam., dimidiate, black; centrum 0.3-0.6 mm diam., globose; exciple dark brown to black. On sheltered calcareous sandstone and schist. V. papillosa
 2. **Spores 30-36 x 11-18 um.** Thallus immersed, whitish, sometimes with black bordering line. Perithecia semi-immersed, 0.25-0.3 mm diam., hemispherical, the excipulum entirely black or brownish black, even in thickness or the tip thickened, the ostiole with small, not sunken mouth; hymenial gel I+ violet; spores elongate, ellipsoid, On calcareous rocks, arctic. V. divergens
3. **Spores subglobose (to broadly ellipsoid), 8-12(-15) x (6-)8-10 um (L:W = 1-1.2).** On chalk rocks, occasionally on slates, probably frequently irrigated by fresh water. Belongs to the V. aethiobola group according to Lynge. (V. arctica)
3. **Spores broadly to narrowly ellipsoid; L:W \geq 1.3).** 4
 4. **Spores 8-10 x 2.5-3 um (commonly 9 x 3 um) [5-7 x 1.5-2 um according to ?].** Thallus very thin, membranaceous, continuous, black or paler. Perithecia semi-immersed in pits in the rock, the apices protruding, 0.1-0.15 mm diam.; involucrellum black, ca. 50 um thick, covering upper third, spreading, the upper part partly projecting at the bone surface to form a fleck 0.005 mm broad; excipulum pale, brown (not observed in lower part). Asci narrowly pyriform; spores narrow, oblong, subcylindrical or slightly fabiform, sometimes narrowed at one end and appearing subpyriform, at tips rounded. On bone or rock, distinctly nitrophilous. Northwest Territories. (See Lichens of Nova Zemlaya for more info.). V. ossiseda Lynge
 4. **Spores over 10 um long and 3 um wide.** 5
5. **Spores narrowly ellipsoid (L:W \geq 2.3).** Perithecia semi-immersed to superficial. 6
5. **Spores ellipsoid to broadly ellipsoid (L:W \leq 2.3).** 7
 6. **Thallus predominantly brown; involucrellum 0.15-0.3(-0.4) mm diam.; spores 11-21(-23) x (4.5-)6-9 um.** Spores narrowly ellipsoid (L:W = 2.3-2.7), sometimes one-septate Thallus immersed, or more commonly superficial, continuous, finely rimose to areolate, pale to dark brown, gray-green or gray-brown, smooth to verruculose, frequently delimited by a dark brown prothallus. Perithecia compound, 1/3-1/2 immersed; involucrellum dimidiate or extending to base-level of true exciple, black; centrum 0.1-0.2(-0.25) mm diam., globose; exciple colorless to brown. On hard limestone. New York. V. pinguicula
 6. **Thallus predominantly green; involucrellum 0.15-0.25(-0.3) mm diam.; spores 11-17 x 4-7.5 um.** Perithecia semi-immersed to almost superficial. Spore L:W = 2.4-2.8. Thallus superficial or almost absent, pale to dark green or olive-brown, diffuse and granular to definite and continuous, rimose or areolate. Perithecia compound, numerous; involucrellum hemispherical to conical, dimidiate, extending to base-level of true exciple,

black; centrum 0.1-0.18(-0.2) mm, globose; true exciple colorless, rarely brown. On limestones, flint, calcareous and non-calcareous sandstones.

Newfoundland. V. dolosa

7. Excipulum usually dimidiate, the lower part pale. Spores to 24 um or more long. 8

7. Excipulum entire, dark brown to black. Spores to 20 um long. 9

8. Hymenium I+ blue becoming violet brownish. Excipulum in upper part brownish black. Spores 17-26 x 8-13 um (L:W = 2-2.1). Thallus almost entirely endolithic, indicated by a whitish color; prothallus absent. Perithecia immersed to emergent, 0.4 mm diam. hemispherical, black; involucrellum present; excipulum dimidiate, the upper part brownish black, the lower pale, inner part of wall pale; ostiole commonly slightly sunken; conceptacle globose, 250-300 um. On calcareous rocks, arctic to temperate, widespread. V. rupestris auct.

8. Hymenium I+ wine red. Excipulum in upper part hyaline to brownish or reddish brown. Thallus immersed to superficial, very variable, pale gray, gray-green, gray-brown or reddish brown, indistinct, continuous, scurfy, delicately pitted, granulose to rimose or areolate, the areoles becoming confluent on smooth substrates; hypothallus indistinct. Perithecia compound, 3/4 immersed to almost superficial, in verrucules, conical, the base broadened, the exposed part subpruinose; involucrellum 0.25-0.4(-0.5) mm diam., dimidiate or, occasionally, extending to exciple-base level, black; centrum 0.2-0.35 mm diam., globose. True exciple colorless to (especially towards outside) pale brown or reddish brown, dimidiate with the sides slightly thickened; ostioles slightly sunken. Spores 18-24(-28) x 8-13(-15) um (L:W = 1.8-2.3). On calcareous rocks, walls and mortar, arctic to temperate, widespread. V. muralis

9. Spores ellipsoid (L:W = 2-2.1), 15-20 x 7-10 um. Similar to V. devergensi but spores smaller and mouth of ostiole sunken. Thallus immersed, whitish, sometimes with black bordering line. Perithecia semi-immersed, 0.25-0.3 mm diam., hemispherical, the excipulum entirely black or brownish black, even in thickness or the tip thickened; hymenial gel I+ violet. On calcareous rocks, Arctic. V. deversa

9. Spores broadly ellipsoid to ellipsoid, (L:W = 1.3-2), 12-20 x 6-12 um. Thallus endolithic, indicated by a gray discoloration of the rock, or epilithic, rimose-areolate, the areoles flat, up to 1 mm broad, dark olivaceous to dark brown, or darker when wet. Conceptacles globose, 100-300 um across. Excipulum black or brown-black. Visible part of perithecia up to 0.2 mm across. Medulla in epilithic thalli black and carbonaceous. Iowa. V. fayettensis

III-A-4. On Calcareous (HCl+) Substrates

Perithecia emergent or sessile.

Thallus epilithic and \pm conspicuous, pale.

1. Perithecia almost all sessile on areole margins, remarkably flattened, Lecidea-like; apex 0.2-0.3 mm; exciple soon dark almost all around. Thallus \pm gray, distinctly and deeply rimose-areolate to areolate, well developed; areoles angular, flat to moderately convex, to 0.8(-1) mm across, pale gray, gray to gray-brown, sometimes darker; upper surface wrinkled or roughened; dark prothallus present or absent. Algae 5-20 μ m. Spores 14-20 x 5-9 μ m. On dry, calcium high rocks. V. lecideoides s. lato

1. Perithecia at least partly immersed, or if \pm sessile then not primarily on areole margins.

..... 2

2. Spores averaging over 25 μ m long and over 12 μ m wide. 3

2. Spores averaging under 25 μ m long and 12 μ m wide. 6

3. Thallus areolate to subsquamulose, often with soredia or isidia on the margins of the areoles. 4

3. Thallus rimose-areolate, without soredia or isidia. 5

4. Areoles 0.4-1.5(-2) mm across, plane to convex, smooth to verruculose, pale brown to olive-green; sterile thalli may have granular soredia or isidia on the margins of areoles. Perithecia compound, 1/2-3/4 immersed but the apical portion conspicuous, up to 0.4 mm across, plane to convex; involucrellum 0.3-0.6 mm diam., thick, dimidiate, black; excipulum dark brown to black; conceptacle (centrum) spherical, up to 200-400 μ m across. Spores 24-28(-37) x (10-)15-17(-20) μ m. Colorado. V. macrostoma

4. Thallus thick, with 2-3 algal layers, which are separated by brown plectenchyma. Areoles subdivided into 0.05-0.3 mm wide subareoles, uniformly brownish colored, without black borders, spots, or dark lines, on the borders breaking into soralia; soralia yellowish, to 0.2 mm long, 0.05 mm wide. Perithecia immersed. Similar to V. macrostoma (and may be a synonym) but almost only on steep or vertical, eutrophicated habitats, on limestone and mortar, often on walls, etc. V. tectorum

5. Spores 18-35 x 10-17 μ m. Thallus thin (< 0.5 mm), brownish (pale or somewhat greenish), sometimes somewhat becoming green on account of "alvado", without black basal layer, rimose-areolate. Perithecia 0.2-0.4 mm, with involucrellum well developed, completely fused with the exciple, covering the upper 1/4, which projects above the rock. On calcareous rocks, walls and mortar. Colorado, Indiana. (V. viridula)

5. Spores 24-40 x 14-24 μ m. Thallus immersed and indistinct to superficial and diffuse, rimose or areolate, pale gray-green or gray-brown, sometimes patchily reddish brown, with or without a dark brown, delimiting prothalline line. Perithecia 1/2-2/3 immersed, compound; apex convex, flat or excavate; involucrellum (0.4-)0.6(-1.0) mm diam., dimidiate, black; centrum 0.3-0.6 mm diam., globose; exciple dark brown to black. On sheltered calcareous sandstone and schist. (V. papillosa)

6. Spores averaging less than 17 μ m long and 7 μ m wide. 7

6. Spores averaging 17-25 μ m long and 7-10 μ m wide. 8

7. Perithecia semi-immersed to almost superficial. Spores 11-17 x 4-7 μ m. Thallus superficial or almost absent, pale to dark green or olive-brown, diffuse and granular to definite and continuous, rimose or areolate. Perithecia compound, numerous; involucrellum 0.15-0.25(-0.30) mm diam., hemispherical to conical, dimidiate, extending to base-level of true exciple, black;

centrum 0.1-0.18(-0.2) mm, globose; true exciple colorless, rarely brown. On limestones, flint, calcareous and non-calcareous sandstones. Newfoundland. V. dolosa

7. Perithecia 2/3 to entirely immersed, Spores 14-20 x 4-7 um. Thallus 0.1-0.3 mm thick; areoles without a black edge, blue-gray (rarely gray, gray-green or gray-brown), edges not blackened, rimose to finely areolate, occasionally with dark brown prothallus. Perithecia compound; involucrellum 0.15-0.3 mm diam., dimidiate, black; apex flat to slightly convex; ostiole often depressed; centrum 0.15-0.25 mm diam., globose; true exciple colorless to black. On hard, rather shaded limestones. California. V. caerulea

8. Excipulum colorless or pale. 9

8. Excipulum dark brown to black. 12

9. Spores narrowly ellipsoid ($L:W \geq 2.3$). 10

9. Spores broadly ellipsoid to ellipsoid ($L:W \leq 2.3$). 11

10. Involucrellum absent. Thallus thick, rimose-areolate, surface of areoles uneven, verrucose, or convex; olivaceous brown. Excipulum colorless to pale brown. Spores (12-)16-24 x 6-9 um ($L:W = 2.7$). Vermont, Mass., Black Hills. V. glaucovirens

10. Involucrellum present, usually dimidiate. Spores narrowly ellipsoid ($L:W = 2.3-2.8$), sometimes one-septate, (11-)16-18(-23) x (4-)6-8(-9) um. Thallus immersed, or more commonly superficial, continuous, finely rimose to areolate, pale to dark brown, gray-green or gray-brown, smooth to verruculose, frequently delimited by a dark brown prothallus. Perithecia compound, 1/3-1/2 immersed; involucrellum 0.15-0.3(-0.4) mm diam., dimidiate or extending to base-level of true exciple, black; centrum 0.1-0.2(-0.25) mm diam., globose; exciple colorless to brown. On hard limestone. New York. V. pinguicula

11. Conceptacle 150-180 um across. Thallus rimose-areolate, areoles 0.2-0.35 mm across (sterile) to 0.5 mm (fertile). Excipulum colorless or pale brown. Spores 18-20 x 8-10 um ($L:W = 2-2.3$). Illinois. V. illinoisensis

11. Conceptacle 200-300 um across. Thallus immersed to superficial, very variable, pale gray, gray-green, gray-brown or reddish brown, indistinct, continuous, scurfy, delicately pitted, granulose to rimose or areolate, the areoles becoming confluent on smooth substrates; hypothallus indistinct. Perithecia compound, 3/4 immersed to almost superficial, in verrucules, conical, the base broadened, the exposed part subpruinose; involucrellum 0.25-0.4(-0.5) mm diam., dimidiate or, occasionally, extending to exciple-base level, black; centrum 0.2-0.35 mm diam., globose; hymenial gel I+ wine red; true exciple colorless to (especially towards outside) pale brown or reddish brown, dimidiate with the sides slightly thickened; ostioles slightly sunken. Spores 18-24(-28) x 8-13(-15) um ($L:W = 1.8-2.3$). On calcareous rocks, walls and mortar, arctic to temperate, widespread. V. muralis

12. Thallus (when dry) brownish to greenish. Spores partly over 27 um long and 14 um wide. Thallus thin (< 0.5 mm), brownish (pale or somewhat greenish), sometimes somewhat becoming green on account of "alvado", without black basal layer, rimose-areolate. Perithecia 0.2-0.4 mm, with involucrellum well developed, completely fused with the exciple, covering the upper 1/4, which projects above the rock. Spores 18-35 x 10-17 um ($L:W = 1.8-2.1$). On calcareous rocks, walls and mortar. Colorado, Indiana. (V. viridula)

12. Thallus (when dry) ashy gray. Spores less than 25 um long and 14 um wide. 13

13. Thallus continuous to verruculose, ashy, or pale olivaceous when wet. Conceptacles

globose, up to 350 um across. Excipulum black or brown-black. Spores 16-24 x 8-14 um (L:W = 1.7-2). Illinois, Wisconsin, Ontario, New York.V. calkinsiana

13. Thallus forming a thin, dull crust of flat areoles to 0.2 mm broad, ashy gray; hypothallus lacking or thin and black. Perithecia 0.2-0.4 mm broad, on verrucules of the thallus, projecting, the base narrowly covered by the thallus, hemispherical; excipulum subglobose, paler, the exterior [involucrellum?] dark brown, dimidiate, thin above, broadening to 50-52 um thick at base Spores 16-27 x 7-14 um (L:W = 1.9-2.3). On rocks, arctic-boreal. The record of this species from Alaska is closer to V. arctica according to Thomson 1997. V. obnigrescens

ADD:

Spores 16-22 x 9-12 um (L:W = 1.8). Thallus thin, rough to indistinctly areolate, "sordid" in color. Perithecia subconical. Excipulum colorless to pale brown. Indiana.V. sordida

Thallus mealy-powdery to finely rimose (areoles ca. 0.35 mm wide), matt, gray-white to pale blue-gray. Perithecia moderately numerous; apex to 0.2(-0.25) mm across; involucrellum reaching halfway or deeper; exciple to 0.18 mm diam. Spores 14-20 um long. Perithecia mostly \pm semi-immersed, falling out and leaving pits or not. Thallus not green when wet. On dry limestone. Ontario; not mentioned in the treatments by Brodo and Wong. V. amylacea

III-A-5. On Calcareous (HCl+) Substrates

Perithecia emergent to sessile.

Thallus epilithic, ± conspicuous, dark.

1. **Spores subglobose (to broadly ellipsoid), 8-12(-15) x (6-)8-10 µm (L:W = 1-1.2).** On chalk rocks, occasionally on slates, probably frequently irrigated by fresh water. Belongs to the V. aethiobola group according to Lynge. (V. arctica)
1. **Spores broadly to narrowly ellipsoid (L:W ≥ 1.3).** 2
 2. **Spores broadly ellipsoid to ellipsoid (L:W ≤ 2).** Medulla black and carbonaceous. 3
 2. **Spores ± narrowly ellipsoid (L:W ≥ 2.3).** Perithecia compound. Exciple colorless or pale. Involucrum present. 6
3. **Visible part of perithecia 0.2-0.4 mm across.** Spores (15-)17-26(-30) x 8-13(-16) µm (L:W = 2-2.1). Thallus moderately thick, areolate, the areoles 0.2-0.8 mm wide, angular, plane to slightly convex, usually smooth (to uneven), occasionally with sorediate or isidiate margins, dark brown to black or blackish green (frequently bright green when wet); medulla black and carbonaceous; prothallus black, also visible beneath the areoles (thin section), occasionally forming a black rim to the areoles. Perithecia compound, 1/2-3/4 immersed; apex flat to hemispherical; involucrum (visible part of perithecia) 0.2-0.4 mm across, dimidiate or extending down to the prothallus, black; centrum (conceptacle) 0.15-0.25 mm diam., globose; hymenial gel I+ wine red; excipulum dark brown; ostiole minute and covered by the thallus, irregular. On calcareous rocks, walls and mortar, more rarely on siliceous rocks, arctic to north temperate, widespread. V. nigrescens
3. **Visible part of perithecia to 0.2 mm across.** 4
 4. **Thallus thick, gray-brown. Spores to 16 µm long and 8 µm wide.** Conceptacle up to 300 µm across (but often smaller!). Spores (9-)11-16 x (4-)6-8 µm (L:W = 1.8-2). Thallus thick, gray-brown. Arizona, Oklahoma, Ontario, Saskatchewan, Northwest Territories. V. fuscella
 4. **Thallus partly endolithic, rimose-areolate, very dark when wet. Spores often partly over 16 µm long and 8 µm wide.** 5
5. **Conceptacle 100-300 µm across.** Spores broadly ellipsoid to ellipsoid, (L:W = 1.3-2), 12-20 x 6-12 µm. Thallus rimose-areolate, the areoles flat, up to 1 mm broad, dark olivaceous to dark brown, or darker when wet. Excipulum black or brown-black. Iowa. V. fayettensis
5. **Conceptacle up to 150 µm across.** Spores 14-23 x 9-12 µm (L:W = 1.6-1.9). Thallus hemi-endolithic, rimose-areolate, dark greenish gray to green-black when wet. Iowa. V. finkiana (= fuscella?)
6. **Thallus predominantly brown; involucrum 0.15-0.3(-0.4) mm diam.; spores 11-21(-23) x (4.5-)6-9 µm.** Spores narrowly ellipsoid (L:W = 2.3-2.7), sometimes one-septate Thallus immersed, or more commonly superficial, continuous, finely rimose to areolate, pale to dark brown, gray-green or gray-brown, smooth to verruculose, frequently delimited by a dark brown prothallus. Perithecia compound, 1/3-1/2 immersed; involucrum dimidiate or extending to base-level of true exciple, black; centrum 0.1-0.2(-0.25) mm diam., globose; exciple colorless to brown. On hard limestone. New York. V. pinguicula
6. **Thallus predominantly green; involucrum 0.15-0.25(-0.3) mm diam.; spores 11-17 x 4-7.5 µm.** Perithecia semi-immersed to almost superficial. Spore L:W = 2.4-2.8.

Thallus superficial or almost absent, pale to dark green or olive-brown, diffuse and granular to definite and continuous, rimose or areolate. Perithecia compound, numerous; involucrellum hemispherical to conical, dimidiate, extending to base-level of true exciple, black; centrum 0.1-0.18(-0.2) mm, globose; true exciple colorless, rarely brown. On limestones, flint, calcareous and non-calcareous sandstones.

Newfoundland. V. dolosa

III-B-1. On non-calcareous (HCl-) substrates.

Perithecia ± completely immersed.

Thallus endolithic or inconspicuous.

No N. American species that I know of.

III-B-2. On non-calcareous (HCl-) substrates.

Perithecia ± completely immersed.

Thallus epilithic, ± conspicuous, pale.

1. Thallus effigurate at margin; marginal areoles radiating, to 3 mm long, 0.5-0.75 mm wide, those towards center angular, 1-1.5 mm broad, areoles flat to slightly convex, bluish gray above, black bordered, with thick black hypothallus which is also on the edges of areoles. Perithecia sunken deeply in areoles, 1-3 per areole, 270 µm wide; ostiole red-brown; exciple pale down to lower layers of hypothallus; hymenial gel I-; spores biseriate or slanting uniseriate, ellipsoid or narrowly ellipsoid, 10-18 x 5-7 µm. On HCL+ rock, Mexico (Yucatan).

"Catapyrenium" radiatum

1. Thallus not effigurate or radiating. 2

2. Spores averaging over 25 µm long and 14 µm wide. Thallus epilithic, 0.3 mm thick, dirty green-gray (often very pale), greener when wet, areolate. Perithecia mostly immersed in the areoles, ampuliform, 0.6-0.7 mm high, 0.3-0.5 mm diam.; exciple entire, completely dark; involucrellum surrounding the ostiole; asci clavate, 8-spored; spores ellipsoid, 24-38(-40) x 13-19(-22) µm. On rocks (calciferous or not), mortar, etc. V. obductilis (Nyl.) Zsch. (Syn.: V. viridula sensu Zsch.)

2. Spores averaging under 25 µm long and 14 µm wide. 3

3. Perithecia immersed in pits in the substrate. Thallus gray-green or lighter, very thin to moderately thick, scurfy to indistinctly chinky-areolate, or areolate. Spores 17-25 x 10-14 µm. Perithecia 0.2-0.3 mm across, black apex (involucrellum) protruding beyond the thallus; spores oblong-ellipsoid to ovoid. Tennessee, Illinois (?), California. V. submuralis

3. Perithecia immersed in the areoles. 4

4. Thallus to 2 mm thick. Areoles somewhat convex. Hymenium I+ blue. Thallus of thick, somewhat convex areoles, either separate or arranged in small groups or finally compacted into a deeply fissured, continuous, chinky crust; surface very minutely granulose, bluish gray, shading off to ashen, K-, C-. Perithecia one to several per areole, immersed; exciple globular, entire, thick, black; ostiole from sunken becoming elevated, circular, thickish; spores 8, simple, hyaline, finally brownish, elongate-ellipsoid, 14.5-22 x 6-8.5 µm. On rocks in foothills, Santa Cruz Peninsula. V. stanfordii

4. Thallus to 0.3 mm thick. Areoles plane. Hymenium I-. Thallus ashy gray, continuous, only partly areolate, superficial. Perithecia immersed in the areoles, with black tips slightly projecting, the excipulum brown-black, thickened around the ostiole. Involucrellum absent. Spores elongate-ellipsoid, 18-28 x 6-10 µm. On acid rocks in wet situations, Alaska. (V. devergescens)

III-B-3. On non-calcareous (HCl-) substrates.

Perithecia \pm completely immersed.

Thallus epilithic, \pm conspicuous, dark.

1. Thallus thin, greenish black to dark olive, effuse to minutely rimose. Thallus wide-spreading. Perithecia 0.2-0.3 mm across, immersed except the black ostiole; wall dimidiate; spores ovoid to ovoid-oblong, 14-17 x 11 μ m. Involucrellum present. On argillaceous rocks, S. California. V. dacryodes

1. Thallus thick, black or dull brownish black, of tough umbonate or reflexed, granular, areolate squamules, over a black hypothallus but may be attached by a thick layer of white hyphae; squamules 0.4-0.8 mm broad, with black borders; in very dry habitats sometimes gray from calcium oxalate pruina. Perithecia 0.25-0.33 μ m diam., embedded in the squamules, only the ostiole projecting; exciple entirely black or with basal portion a little paler; hymenial gel I+ blue; spores ovate or ellipsoid, 12-17 x 6-9 μ m. On calcareous rocks in the open, Utah, New Mexico, Colorado, Wyoming; Alberta. V. compacta

III-B-4. On non-calcareous (HCl-) substrates.

Perithecia emergent to sessile.

Thallus endolithic or inconspicuous.

1. Spores 21-28(-30) x (10-)13-15 μ m. Thallus obsolete or very thin, gray-white or gray-yellow. Perithecia globose, 0.15-0.25 mm diam., epilithic, appressed to substrate, numerous, regularly dispersed, black, matt, not depressed at ostiole; involucrellum thick, dimidiate, carbonaceous, not distinctly delimited from exciple; exciple entire, black. Hymenial gel I+ red. On hard, HCl- slate. Arctic. V. obsoleta

1. Spores averaging < 21 μ m long and 10 μ m wide. 2

2. Spores 11-21 x (5-)7-10 μ m. Thallus very thin, dull, continuous or broken up, or almost lacking, but never rimose, black-brown; cortex brown, of a single layer of cells.

Perithecia hemispherical to nearly spherical, sunken into thallus only at the base, naked at apex, 0.1-0.2 mm broad, black, the ostiole a narrow point; exciple brown, surrounded by a black-brown involucrellum which extends below as well as on the sides (according to Thomson 1997; involucrellum absent according to ?); interior I+ red; spores biseriate, ellipsoid. On granitic rocks in shade or in the open. Arctic. V. acrotella

2. Spores 8-10 x 2.5-3 μ m (commonly 9 x 3 μ m). Thallus very thin, membranaceous, continuous, black or paler. Perithecia semi-immersed in pits in the rock, the apices protruding, 0.1-0.15 mm diam.; involucrellum black, ca. 50 μ m thick, covering upper third; excipulum pale, brown (not observed in lower part). Asci narrowly pyriform; spores narrow, oblong, subcylindrical or slightly fabiform, sometimes narrowed at one end and appearing subpyriform, at tips rounded. On bone or rock [may be calcareous only], distinctly nitrophilous. (See Lichens of Nova Zemlaya for more info.). Not mentioned by Thomson 1997..... (V. ossiseda Lynge)

III-B-5. On non-calcareous (HCl-) substrates.

Perithecia emergent to sessile.

Thallus epilithic, \pm conspicuous, pale.

1. Thallus thick, distinctly areolate, subsquamulose. Spores broadly ellipsoid to mostly globose, 12.5-18 x 7-7.5 μ m ellipsoid or 7-12 μ m when globose. Thallus gray, densely pruinose, areolate; areoles 1-4 mm broad, slightly convex, angular, partly subdivided, surface cracked; underside dark brown to black. Perithecia 1-several per areole; upper 1/5-1/4 partly projecting; ca. 0.25-0.35 mm diam.; inner 35-40 μ m of exciple brown, outer ca. 50 μ m dark brown-black entirely around perithecium; hymenial gel I-; spores biseriate, . On steeply sloping irrigated granite, Colorado. "Catapyrenium" globosum Thomson

1. Thallus thin, distinctly crustose. Spores ellipsoid, 16-27 x 7-14 μ m (L:W = 1.9-2.3). Areoles flat, to 0.2 mm broad, ashy gray; hypothallus lacking or thin and black. Perithecia 0.2-0.4 mm broad, on verrucules of the thallus, the base narrowly covered by the thallus, hemispherical; excipulum subglobose, paler, the exterior [involucrum?] dark brown, dimidiate, thin above, broadening to 50-52 μ m thick at base. On rocks, arctic-boreal. V. obnigrescens

III-B-6. On non-calcareous (HCl-) substrates.

Perithecia emergent to sessile.

Thallus epilithic, \pm conspicuous, dark.

1. Thallus very thin, continuous or broken up, or almost lacking, but never rimose, black-brown, dull. Perithecia hemispherical, sunken into thallus at the base, naked at apex (involucrellum absent), conspicuous. Spores 11-21 x (5-)7-10 μ m. Alaska, NW Territories.V. acrotella

1. Thallus \pm thick, more or less rimose-areolate. 2

2. Spores narrowly ellipsoid to oblong (L:W averaging \geq 2.5). 3

2. Spores \pm ellipsoid (L:W averaging $<$ 2.5). 5

3. Excipulum black. Spores 12-18 x 4-7 μ m (L:W = 2.6-3). Thallus epilithic, thin to very thin, smooth to slightly rough, becoming areolate or granular, grayish brown to greenish brown to dull black. Perithecia 0.1-0.3 mm diam., dimidiate, numerous, \pm immersed, the superficial portion (involucrellum) subhemispherical, dull black. Spores ellipsoid, irregularly arranged. Minnesota, Black Hills.V. nigrescentoidea

3. Excipulum hyaline or pale brown. Spores L:W averaging \leq 2.6. 4

4. Involucrellum present. Spores 11-17 x 4-7 μ m (L:W = 2.4-2.8). Perithecia semi-immersed to almost superficial. Spores 11-17 x 4-7 μ m (L:W = 2.4-2.8). Thallus superficial or almost absent, pale to dark green or olive-brown, diffuse and granular to definite and continuous, rimose or areolate. Perithecia compound, numerous; involucrellum 0.15-0.25(-0.30) mm diam., hemispherical to conical, dimidiate, extending to base-level of true exciple, black; centrum 0.1-0.18(-0.2) mm, globose; true exciple colorless, rarely brown. On limestones, flint, calcareous and non-calcareous sandstones. Newfoundland. (V. dolosa)

4. Involucrellum absent. Spores (12-)16-24 x 6-9 μ m (L:W = 1.7-2.7). Thallus olivaceous brown, thick, rimose-areolate, surface of areoles uneven, verrucose, or convex. Excipulum colorless to pale brown. Vermont, Mass., Black Hills. (V. glaucovirens)

5. Thallus dark brown to olive brown or blackish, moderately thick, uneven-verrucose or granular to rimose-areolate, forming a discontinuous crust, dull, with a margin of fimbriate hypothallus hyphae. Perithecia 0.15-0.2 mm broad, partially emergent (half immersed in the areolae), conical to hemispherical; excipulum blackish, entire around the perithecium. Involucrellum absent or not well differentiated from the exciple, black; gelatin I+ red. Spores elongate or ellipsoid, (9-)12-20(26) x 5-9(-11) μ m (L:W = 2.2-2.4). On granitic and schistose rocks. Illinois; Arctic.V. umbrinula

5. Thallus at least partly paler. 6

6. Spores 12-20 x 6-12 μ m, broadly ellipsoid to ellipsoid (L:W = 1.3-2). Thallus endolithic, indicated by a gray discoloration of the rock, or epilithic, rimose-areolate, the areoles flat, up to 1 mm broad, dark olivaceous to dark brown, or darker when wet. Conceptacles globose, 100-300 μ m across. Excipulum black or brown-black. Visible part of perithecia up to 0.2 mm across. Medulla in epilithic thalli black and carbonaceous. Iowa.V. fayettensis

6. Spores at often partly over 20 μ m long, ellipsoid or narrowly ellipsoid. 7

7. Involucrellum absent. Spores (12-)16-24 x 6-9 μ m (L:W = 1.7-2.7). Thallus olivaceous brown, thick, rimose-areolate, surface of areoles uneven, verrucose, or convex. Excipulum

colorless to pale brown. Vermont, Mass., Black Hills. (V. glaucovirens)

7. Involucrum present. Spores 18-24(-28) x 8-13(-15) um (L:W = 1.8-2.3). Thallus immersed to superficial, very variable, white to pale gray, gray-green, gray-brown or reddish brown, indistinct, continuous, scurfy, delicately pitted, granulose to rimose or areolate, the areoles becoming confluent on smooth substrates; hypothallus indistinct. Perithecia compound, 3/4 immersed to almost superficial, in verrucules, conical, the base broadened, the exposed part subpruinose; involucrum 0.25-0.4(-0.5) mm diam., dimidiate or, occasionally, extending to exciple-base level, black; centrum 0.2-0.35 mm diam., globose; hymenial gel I+ wine red; true exciple colorless to (especially towards outside) pale brown or reddish brown, dimidiate with the sides slightly thickened; ostioles slightly sunken. (V. muralis)

III-C.

Lichenicolous on lichens over various rock types

1. Ascospores 12-15(-16) x 7-9(-10) um. Perithecia without involucrum, periphyses to 35 um long, hymenium always without oil droplets. Areolae with lateral and lower cortices.

Pycnospores 5-7.5 um long, straight. V. lesdainii Breuss

1. Ascospores (18-)20-25(-27) x (8-)9-12 um. Perithecia with involucrum which envelops at least the upper half of the perithecium. Periphyses to 50 um long, hymenium often inspersed with oil droplets (especially in the area of the ostiolum). Areolae without lateral and lower cortices. Pycnospores 7.5-10 um, often slightly curved. V. inficiens Breuss

IV. On Soil.

Perithecia with an involucrellum, compound, 0.25-0.5(-0.75) mm diam.; goniocysts absent. (V. muralis)

ADD:

Thallus chinky-areolate, with flat or slightly convex areolae, gray-brown or yellow-brown, dull, moderately thick, to 0.4 mm thick. Perithecia in raised portions of the areolae, covered by thallus tissue, the ostiole flattened; exciple greenish black, entire; involucrellum extending down as far as the base of the perithecium; gelatin I+ red; asci broadly saccate; spores ellipsoid, 14-21 x 7.5-10 um. On calcareous and non-calcareous rocks in damp but not aquatic sites.

Arctic. V. cataleptoides (Nyl.) Nyl.

V. novomexicana de Lesd.

V. phaeothelena Th. Fr.

V. pseudonigrescens Servit

V. ruderella Nyl.

V. sorbicola Servit

V. subglaucina de Lesd.

Arizona. V. trabicola Arn.

Thallus dark brown, subsquamulose; areoles finely crenulate-lobulate, densely aggregated. Spores broadly ellipsoid, 10-16 x 5.5-7.5 um. Parasitic on Staurothele areolata, eventually becoming independent. Colorado, Montana. "V. zamenhofiana Clauz. & Roux

Thallus "areolate" (= ? Verrucaria spp.):

"Catapyrenium" caeruleopulvinum Thoms.

Thallus light bluish gray to medium gray, pruinose, areolate, the areoles rounded to angular, 1-4 mm broad, the upper surface very rounded convex, almost bullate; cortices and medulla paraplectenchymatous; upper cortex to ca. 25 um thick; algal layer appearing as columns of algae; lower cortex thick, purplish brown; lower side black, attached to substratum for greater part of each areole by dark hyphae, not rhizoids, not umbilicate. Perithecia numerous in each areole, the mouth inconspicuous and showing in the upper surface only as a very minute, deeply embedded, dark dot; exciple pale except near ostiole where its cells darken; spores uniseriate to usually biseriate, ellipsoid to elongate ellipsoid, 10-20 x 6-8 um. On rocky soils. Arizona, California.

"Catapyrenium" radiatum Thomson

Thallus effigurate at margin; marginal areoles radiating, to 3 mm long, 0.5-0.75 mm wide, those towards center angular, 1-1.5 mm broad, areoles flat to slightly convex, bluish gray above, black bordered, with thick black hypothallus which is also on the edges of areoles. Perithecia sunken deeply in areoles, 1-3 per areole, 270 um wide; ostiole red-

brown; exciple pale down to lower layers of hypothallus; hymenial gel I-; spores biseriate or slanting uniseriate, ellipsoid or narrowly ellipsoid, 10-18 x 5-7 um. On HCL+ rock, Mexico (Yucatan).

"Catapyrenium" globosum Thomson

Thallus gray, densely pruinose, areolate; areoles 1-4 mm broad, slightly convex, angular, partly subdivided, surface cracked; underside dark brown to black. Perithecia 1-several per areole; upper 1/5-1/4 partly projecting; ca. 0.25-0.35 mm diam.; inner 35-40 um of exciple brown, outer ca. 50 um dark brown-black entirely around perithecium; hymenial gel I-; spores biseriate, broadly ellipsoid to mostly globose, 12.5-18 x 7-7.5 um ellipsoid or 7-12 um when globose. On steeply sloping irrigated granite, Colorado.

"Catapyrenium" granulorum (B. de Lesd.) Thoms. (Syn. Endopyrenium granulorum, and [presumably; type not found] E. crustaceum)

Thallus areolate; areoles to 0.5 mm broad, flat, irregular, the edges granular, becoming larger and more granular to 3 mm broad and 0.5 mm thick, \pm angular; upper side ashy brown to blackish, the granules gray; underside dark. Perithecia immersed, the mouth showing as a dark spot; exciple dark; hymenial gel I \pm wine red; spores ellipsoid to oblong, 24-28 x 7-9 um (15-16 x 6-8 um in "Endopyrenium crustaceum", type not seen but treated by Thomson as a synonym). On HCl+ rock, New Mexico.

"Catapyrenium" zahlbruckneri (Hasse) Thoms. (Syn. Dermatocarpon zahlbruckneri)

Thallus squamulose-areolate; areoles 0.5-1 mm broad, convex above, round to more usually angular, gray; upper cortex paraplectenchymatous with vertically arranged cells; lower cortex thin, attached by rhizoidal hyphae. Perithecia 130 um diam., immersed, 1 to few per areole; ostiole dark, rest of exciple pale; hymenial gel I-; asci becoming saccate or ventricose (according to Fink; if correct, that's closer to clavate than to cylindrical). spores uniseriate to biseriate, ellipsoid, 17-24 x 4-7 um. Pycnidia immersed; pycnospores ellipsoid-fusiform, 12 x 2 um. On calcareous or acidic rocks, California (?), Arizona, NW Mexico. According to Breuss & McCune, the species belongs neither to Catapyrenium nor Dermatocarpon.

Also see the seven "sp."s in Harris 1995.

Detailed Descriptions

V. acrotella Ach.

V. aethiobola Wahlenb.

V. amphibola Clemente

V. amylacea Hepp

V. applanata Hepp ex Zschacke

V. aquilella Nyl. = V. aethiobola (see Hawksworth)

V. arctica Lynge

Thallus thin to moderately thick, brown to gray-black, matt; areoles smooth, small, convex to verrucose, discrete or \pm confluent, forming areolate-verrucose crust (with minute argillaceous granules between the areoles), or reduced to a few small verrucae around the perithecia. Algal layer 125 μ m, algae densely crowded, not distinctly seriate.

Perithecia frequent, 1/2 to 1/3 immersed in thalline areoles; upper part prominent, at tips nitid, around ostiole not or slightly impressed; perithecia globose, 0.25-0.4 mm diam.; excipulum entire, black-fuliginous, rather fragile, upper 1/2-2/3 covered by a thick carbonaceous involucrellum; involucrellum and excipulum not separated, but a clearing by chloral hydrate will often loosen the involucrellum; asci narrow, 50-55 x 12-14 μ m, often subcylindrical, spores uniseriate, broadly ellipsoid to subglobose, 8-12(-15) x (6-)8-10 μ m. Hymenial gel I+ red.

On chalk rocks, occasionally on slates, probably frequently irrigated by fresh water.

Belongs to the V. aethiobola group.

V. caerulea DC.

Thallus epilithic, small, rimose-areolate, ash gray, in shade greenish gray, areoles 0.1-0.5 mm wide, without hypothallus.

Perithecia 0.1-0.22 mm, almost completely immersed, with flattened apex; involucrellum relatively thin, folded around, and reaching the base of the perithecium; centrum rounded, 0.1-0.15 mm, matrix 0.3% I+ red; asci 53-69 x 16-19 μ m; spores 11-17 x 4-7 μ m.

On stone walls not manured by birds; sometimes also on weathered rocks and in shaded and moist habitats. Especially on rain-exposed slopes and vertical surfaces. Calcicolous.

Superficially similar to V. fuscella, but lacks dark hypothallus.

V. calciseda DC.

Thallus endolithic, chalky white, usually with dark prothallus at margin, sometimes with minute dots, when young concolorous with rock, surface smooth, but often uneven; macrosphaeroids not present.

Perithecia sometimes sparsely distributed, immersed, leaving pits, sometimes surrounded by warty swellings which can be fissured, 0.15-0.30 mm wide, when mature only 0.05 mm of the perithecium visible at surface; centrum rounded, 0.22-0.39 mm wide, with black, thick exciple, thickened at apex, without involucrellum; matrix 0.3% I+ blue (soon partly changing into red), 1%

I+ brown-red (partly blue-green); asci 63-115 x 26-44 μm ; spores (13-)15-28 x 6.5-15 μm .

On north-exposed surfaces of stone walls, weathered cracks and steep or vertical faces, especially in light, usually sun-exposed habitats, avoiding places with strong manuring. Calicicolous.

V. calkinsiana Servit

V. canella Nyl.

Spores 13.5-32 x 7-9 μm ; otherwise agrees well with V. fuscella, according to Froberg 1989, who synonymized it under that species.

V. cataleptoides (Nyl.) Nyl.

Thallus chinky-areolate, with flat or slightly convex areolae, gray-brown or yellow-brown, dull, moderately thick, to 0.4 mm thick.

Perithecia in raised portions of the areolae, covered by thallus tissue, the ostiole flattened; exciple greenish black, entire; involucrellum extending down as far as the base of the perithecium; gelatin I+ red; asci broadly saccate; spores ellipsoid, 14-21 x 7.5-10 μm . On calcareous and noncalcareous rocks in damp but not aquatic sites.

V. ceuthocarpa Wahlenb.

Thallus deeply chinky-areolate, continuous, piled up, the chinks widely separating the areolae, which are 0.2-0.5 mm broad, black, dull, the surface uneven but lacking pegs or ridges, the hyphae of the interior \pm vertical and the algae in vertical rows.

Perithecia very tiny, 0.1-0.15 mm, immersed, tips only slightly raised above thallus level; exciple hyaline and only blackened for a short distance around the ostiole; lacking involucrellum or with a slight brown one at the ostiole; interior gelatin I+ red; spores ellipsoid or broadly ellipsoid, 8-10 x 5-8 μm . On acid rocks in marine habitats. Very similar to V. mucosa, differing mainly in the greater areolation of the thallus and the slightly shorter spores.

V. compacta (Massal.) ____

(Syn. Catapyrenium compactum (Massal.) R. Sant., Dermatocarpon compactum, and [presumably; types not found] Endopyrenium rupicola and E. americanum)

Thallus a thick black or dull brownish black crust of tough umbonate or reflexed, granular, flattened, angular, areolate squamules, over a black hypothallus but may be attached by a thick layer of white hyphae; squamules 0.4-0.8 mm broad, \pm umbonate, with black borders; in very dry habitats sometimes gray from calcium oxalate pruina. Perithecia 0.25-0.33 μm diam., embedded in the squamules, only the ostiole projecting; exciple entirely black or with basal portion a little paler; hymenial gel I+ blue; spores ovate or ellipsoid, 12-17 x 6-9 μm . On calcareous rocks in the open, Utah, New Mexico, Colorado, Wyoming; Alberta.

V. dacryodes Nyl.

V. degelii R. Sant.

V. devergens Nyl.

V. deversa Vainio

V. dolosa Hepp

V. ditmarsica Erichsen

V. elaeomelaena (Massal.) Arnold

V. epimaura Brodo

Thallus clearly visible, thick (0.25-0.65 mm). Thallus edge definite, usually distinctly lobate, with very short, broad lobes. Thallus mostly continuous, \pm smooth, or areolate in older parts of thallus, with abundant, punctiform or elongate jugae forming thin, radiating, black ridges, ca. 0.03-0.05 mm thick, \pm branched, most easily visible when thallus is first moistened, not quite reaching the thallus edge. Thallus dark yellow-brown to black when dry and pitch black and gelatinous when wet, with a thick, black, basal medullary layer producing vertical extensions that become the black jugae. Photobiont chlorococcoid; cells squarish, (6-)10-12 μ m diam., arranged in vertical columns.

Perithecia occurring singly, entirely immersed in thallus, with only the ostiole barely visible. Involucrellum carbonaceous, merging with medullary tissue. Excipulum entirely distinct from involucrellum, pale. Centrum 160-190 μ m high, 140-250 μ m wide, hyaline. Periphyses conspicuous, stout, stiff, 2.0-2.5 μ m thick, 10-12 μ m long. Spores 7-10 x 6.5-7.5(-8) μ m, 8 per ascus, hyaline, subglobose, L:W = c. 1.2-1.4.

Pycnidia sparse, immersed in thallus, cylindrical; conidia bacillariform to ellipsoid, ca. 4.5-5.5 x 1-2 μ m.

On non-calcareous shoreline rocks.

V. fayettensis Servit

V. finkiana Servit

V. funckii (Sprengel) Zahlbr.

V. fuscella (Turner) Winch

Thallus small, epilithic, rimose-areolate, ash-gray to brown-gray, relatively thin, areoles 0.15-0.5 mm wide, angled but even margin; hypothallus visible as a black rim.

Perithecia 1-3 per areole, situated at the edge, immersed, flattened, visible on surface as 0.1-0.25 mm wide, black patches; involucrellum well developed, reaching the base of the perithecium; centrum rounded, 0.14-0.22 mm, with a black exciple; matrix 0.3% I+ red; asci 43-60 x 16-25 μ m; spores 9-20 x 3.5-9 μ m, sometimes 1-septate.

On stone walls and other rocks not manured by birds, and larger stones among gravel; often epiphytic on V. nigrescens; on steep surfaces and stones; in small crevices or ledges on vertical surfaces. Calcicolous. Boreal to mediterranean.

Similar to V. glaucina [auct.] but is characterized by rather small and thin, ash-gray areoles, perithecia usually 1 per areole, with black exciple and well developed involucrellum folded around the centrum, reaching the base of the perithecium and continuous with the dark hypothallus.

V. fusconigrescens Nyl.

V. glaucovirens Grumann

V. halizona Leighton

V. hydrela Ach.

V. illinoisensis Servit

V. inficiens Breuss

Morphologically very similar to V. lesdainii. Without paraplectenchymatous lateral and lower cortices.

Involucrum well-developed, circles at least around the upper part of the perithecium, later extending to base of perithecium and sometimes enveloping the whole ascoma. Periphyses to 50 µm long. Hymenium interspersed with oil droplets (especially in the area of the ostiole). Spores (18-)20-25(-27) x (8-)9-12 µm.

Pycnidia Staurothele-type; pycnospores 7.5-10 µm, often slightly bent.

On Staurothele areolata over sandstone, Colorado and New Mexico.

V. integra (Nyl.) Nyl.

Thallus within the rock, making a gray-white to gray-brown spot. Perithecia immersed in the rock, only the ostiole visible; exciple and involucrum fused to appear as one, wrapping around the perithecium, slightly thicker at the ostiole, brownish black; gelatin I+ blue; spores broadly ellipsoid, blunt, 23-30 x 15-17 µm. On calcareous rocks. Alaska.

V. internigrescens (Nyl.) Erichsen

V. lecideoides (Massal.) Trevisan

V. lesdainii Breuss (syn. Catapyrenium plumbeum)

Thallus areolate, whitish or bluish gray, dull, ± roughly pruinose. Areoles (0.5-)1-2(-2.5) mm, close together or becoming separate, flat to slightly convex, angular to somewhat rounded, rarely slightly incised (especially those at thallus margin), basally ± constricted, fastened to the substratum by a central hyphal bunch, free marginal parts of lower side pale brown to blackish, no hypothallus visible. Areoles 200-400 µm thick (up to 1 mm including the “stipe”), upper cortex 15-20 µm thick, of small roundish-angular cells (4-6 µm diam.), outer cell layer brownish, overlain by a thickish amorphous layer (20-40 µm). The cortical paraplectenchyma continues laterally down to the free lower sides of the areoles. Algal layer continuous, algal cells 7-10 µm diam., alga-free medullary tissue ± cellular or with filamentous parts, especially near the attachment organ which is formed largely by longitudinally arranged hyphae with substratum particles in between.

Perithecia within the areolae, 1 to several per areole, entirely sunken or with slightly protruding tips. Exciple pale at first and black around the ostiole, then darkening throughout, subglobose or pyriform, to 350(-500) µm broad, without involucrum. Periphyses 25-35 µm long

and 2.5-3 μm thick. Asci clavate, 60-75 x 15-23 μm . Spores biserially arranged, broadly ellipsoid, 12-16 x 7.5-10 μm .

Pycnidia of Staurothele-type, small (to 80 μm diam.), visible as small black irregular dots often in small depressions of the areoles. Pycnosporos cylindrical, 5-7.5 x 1 μm .

On Staurothele (mostly S. areolata), mostly over sandstone, Arizona, Colorado, Utah, Wyoming.

V. lobata J. W. Thomson

Thallus dark gray to reddish brown, with radiating border areoles to 2 mm long, 0.2 mm wide, partly in lines, areoles in thallus center more angular when sterile to becoming almost spherical when bearing perithecia; a darkened 20-cell-thick superficial layer is over the cortex which has groups of algae distributed within.

Perithecia single in nearly spherical areolae to center of thallus, completely immersed, only the mouth showing as a tiny dark dot which partly shows a whitened central dot where periphyses are present at the opening; excipulum subcompound, pale below, dark around the mouth; lower part of excipulum hyaline, contents I+ red; spores 8, ellipsoid-elongate, 22-28 x 8-10 μm . On calcareous shale, British Columbia.

V. macrostoma Dufour ex DC.

Thallus epilithic, rimose-areolate, with broad fissures, chestnut-brown or yellow-brown; areoles 0.2-1 mm wide, with even surface, without hypothallus.

Perithecia black and clearly contrasting against the lighter thallus; involucrellum usually indistinct, not reaching the middle of the perithecium; centrum elongated, 0.53-60 x 0.23-0.48 mm, with black, thick exciple; matrix 0.3% I+ red; asci 68-108 x 33-44 μm ; spores 17-36 x 8-20 μm .

On drier patches of pavements; on dust impregnated walls, limestone pavements, vertical surfaces, overhangs and in manured places.

Differs from V. nigrescens in having a lighter thallus with broader cracks, and by the absence of a dark hypothallus (though some specimens have a dark medulla, it has calcium oxalate, not found in the hypothallus of V. nigrescens).

V. margacea (Wahlenb.) Wahlenb.

V. marmorea (Scop.) Arnold

V. maura Wahlenb.

V. melas Herre

Thallus thin or very thin, effuse, microscopically areolate and intricately fissured, appearing to naked eye as a daub of dead black paint, K-, C-.

Perithecia numerous, at first low and covered by thallus, becoming more prominent and emergent, hemispherical, finally sessile and subglobose, apical portion then irregularly depressed and ostiole comparatively large; exciple entire, black; asci ovoid, clavate, and pyriform; hymenial gel I+ blue; spores ellipsoid, 19.5-27 x 8.5-12.5 μm .

Rare, on rocks a few feet above the sea at Pt. Lobos (Monterey), associated with Pyrenocollema halodytes.

Strongly resembling V. maura in general appearance, but differs in thinner thallus, much larger and differently shaped spores, and I+ blue (not red) reaction of hymenium.

V. mucosa Wahlenb.

V. muralis Ach.

Thallus epilithic, thin, continuous or cracked to granular-areolate, light to dark gray, grayish brown or grayish green, often covered with cyanobacteria, without hypothallus.

Perithecia half-immersed, sometimes leaving pits, with thin involucrellum folded around the centrum, reaching beyond the middle of the perithecium; centrum rounded, 0.2-0.41 mm, with light to dark, thin exciple, matrix 0.3% I+ red; asci 62-107 x 20-50 um; spores 13-33(-36) x 7-18 um.

In \pm shaded habitats and on gravel; on larger rocks as well as pebbles as a pioneer; also in larger crevices. Calcicolous. (Arctic-)boreal to mediterranean

V. nigrescens Pers.

Thallus epilithic, relatively thin, rimose-areolate, with narrow fissures, dark brown to almost black (in shade greenish); areoles 0.1-1.5 mm wide, with even surface; photobiont layer gathered into islands in the upper part of the thallus.

Perithecia half-immersed, usually 1/areole; involucrellum well developed, continuous with a dark hypothallus which occupies the lower part of the thallus; centrum 0.13-0.31 mm wide, with black exciple; matrix 0.3% I+ red; asci 51-98 x 28-40 um.

On stone walls and other rocks which are not manured, dry or slightly inundated pavements and gravel.

V. nigrescentoidea Fink

V. novomexicana de Lesd.

V. obductilis (Nyl.) Zsch. (Syn.: V. viridula sensu Zsch.)

[Description after Clauzade & Roux]: Thallus very thick (0.5-2 mm), white to greenish gray or reddish gray; areoles coarse (0.5-2 mm), of "skvamet" aspect, often \pm lobed; medulla white to brown or black. Perithecia 0.4-0.5 mm diam., with involucrellum present only around the ostiole and excipulum \pm bottle-shaped, immersed or almost immersed, with black exciple and involucrellum. Spores 21-40 x 13-22 um.

[Description after ?; may be based on V. viridula]: Thallus epilithic, 0.3 mm thick, dirty green-gray (often very pale), greener when wet, areolate. Perithecia mostly immersed in the areoles, ampuliform, 0.6-0.7 mm high, 0.3-0.5 mm diam.; exciple entire, completely dark; involucrellum surrounding the ostiole; asci clavate, 8-spored; spores ellipsoid, 24-38(-40) x 13-19(-22) um. On rocks (calciferous or not), mortar, etc.

V. obnigrescens Nyl.

V. obsoleta Lynge

Thallus obsolete or very thin, gray-white or gray-yellow.

Perithecia globose, 0.15-0.25 mm diam., epilithic, appressed to substrate, numerous, regularly dispersed, black, matt, not depressed at ostiole; involucrellum thick, dimidiate, carbonaceous, not distinctly delimited from exciple; exciple entire, black. Spores 21-28(-30) x (10-)13-15 μ m. Hymenial gel I+ red.

On hard, HCl- slate. Arctic.

V. ossiseda Lyng

Thallus very thin, membranaceous, continuous, black or paler. Perithecia semi-immersed in pits in the rock, the apices protruding, 0.1-0.15 mm diam.; involucrellum black, ca. 50 μ m thick, covering upper third; excipulum pale, brown (not observed in lower part). Asci narrowly pyriform; spores narrow, oblong, subcylindrical or slightly fabiform, sometimes narrowed at one end and appearing subpyriform, at tips rounded, 8-10 x 2.5-3 μ m (commonly 9 x 3 μ m). On bone or rock, distinctly nitrophilous. (See Lichens of Nova Zemlaya for more info.).

V. papillosa Ach.

V. phaeothelena Th. Fr.

V. pinguicula A. Massal.

V. praetermissa (Trevisan) Anzi

V. pseudonigrescens Servit

V. rheitrophila Zschacke

V. riddleana R. C. Harris (syn. V. mamillaris Riddle)

Florida. Not in my keys.

V. ruderella Nyl.

V. rupestris Schrader

V. sandstedei de Lesd.

V. schofieldii Brodo

Thallus clearly visible, thin, or rarely thick in spots (0.04-0.12 mm). Thallus edge indefinite or definite, not lobate. Thallus continuous, slightly rimose in thicker places, \pm smooth, shiny, without jugae, or with scattered, often inconspicuous jugae that are punctiform, tiny, smaller than those in V. maura. Thallus dark, medium olive-brown to gray-olive or medium olive, gelatinous when wet; without a black, basal medullary layer, or with a thin brown layer at the rock interface (The thallus of herbarium specimens turns black permanently after being wetted with fresh water). Soredia absent. Prothallus absent. Photobiont chlorococcoid, cells 7-9 μ m diam., not arranged in columns.

Perithecia discrete, occurring singly or clustered in groups, black or almost black, partially

or entirely covered with thallus tissue, but forming a distinct bump on the thallus, 1/2 to 3/4 visible, 0.25-0.45 mm diam., conical. Ostioles level with perithecial surface. Involucrellum thick, carbonaceous, sometimes extending out into the medulla as a collar, completely enclosing centrum. Excipulum distinct from involucrellum at least at base, or not distinguishable from involucrellum; carbonaceous or darkly pigmented, c. 20-25 µm thick. Centrum 170-200 µm high, 170-200 µm wide, hyaline. Hypothecium colorless or almost so. Periphyses conspicuous. Spores 8 per ascus, hyaline, ellipsoid, 11.5-14.5(-16) x 6.5-7.5(-8) µm, L:W = 1.7-2.1.

Pycnidia commonly seen, entirely buried in thallus; conidia short, bacillariform, 4-8 x 0.9-1.1 µm.

Growing directly on siliceous, or rarely calcareous shoreline rocks, lower hygrohaline or, less frequently, upper hygrohaline zone. Queen Charlotte Islands to SE Alaska.

V. silicicola Fink

V. sorbicola Servit

V. sordida Servit

V. sphinctrina Ach. (*Bagliettoa sphinctrina*--genus accepted by Wirth's most recent treatment)

Involucrellum c. 0.4 mm wide, slightly swollen in center and \pm surpassing the upper surface of the thallus, radially furrowed or cracked; perithecia 0.3-0.35 mm wide, completely immersed, only the involucrellum visible. Receptacle brown or partially even pale. Spores 18-20(-35) x 10-13 µm, very rarely mixed with weakly septate ones. Thallus thin, uniform, endolithic or weakly epilithic, sordid whitish to white, with spherical "macrosphaeroids". On limestone or dolomite.

V. stanfordi Herre

Thallus of thick, somewhat convex areoles, reaching a thickness of 2 mm, either separate or arranged in small groups or finally compacted into a deeply fissured, continuous, chinky crust; surface very minutely granulose, bluish gray, shading off to ashen, K-, C-.

Perithecia one to several per areole, immersed; exciple globular, entire, thick, black; ostiole from sunken becoming elevated, circular, thickish; hymenial gelatin I+ blue; spores 8, simple, hyaline, finally brownish, elongate-ellipsoid, 14.5-22 x 6-8.5 µm.

On rocks in foothills, Santa Cruz Peninsula

V. striatula Wahlenb.

V. subglauca de Lesd.

V. submersella Servit

V. submuralis Nyl.

V. tavaresiae R. Moe

THALLUS continuous, 0.25-1 mm thick, subcoriaceous, smooth, matt, black, when very

dry grayish-buff, with thin blackish-brown margin, irregular black cracks, and minute black spots, when wet dark brownish- or greenish-black; cortical layer < 5 µm thick; algal layer c. 75 µm thick; medulla of densely packed, thin-walled, \pm isodiametric cells, becoming more filamentous close to the substrate and near the margins; algae Petroderma maculiforme (Phaeophycophyta), forming straight, anticlinal filaments; cells 6-10 µm diam., \pm isodiametric.

PERITHECIA sparse or crowded, completely immersed, flask-shaped, 300-500 µm diam. at surface, 200-250 µm diam. internally; excipulum brownish when mature; involucrellum black, irregular in outline; periphyses 1.5-2 µm thick, to 30 µm long, sometimes branched but not anastomosing; hymenial gel I+ light blue; asci clavate, 40 µm long; spores 8, ellipsoid, 12-15 x 5-7 µm.

PYCNIDIA abundant, completely immersed, unilocular or \pm multilocular, of varying shape and size; ostioles black, c. 100 µm diam.; conidia filiform, 8 x 0.5 µm.

ECOLOGY AND DISTRIBUTION: On rock, middle to upper intertidal zone, California.

Verrucaria tectorum (Massal.) Koerber

Thallus thick, with 2-3 algal layers, which are separated by brown plectenchyma. Areoles in subdivided into 0.05-0.3 mm wide subareoles, uniformly, brownish colored, without black borders, spots, or dark lines, on the borders breaking into soralia; soralia yellowish, to 0.2 mm long, 0.05 mm wide.

Perithecia immersed.

Similar in to V. macrostoma but almost only on steep or vertical, eutrophicated habitats, on limestone and mortar, often on walls, etc.

V. thalassina (Zahlbr.) Zsch.

Greenland. See Thomson 1997 for description

V. trabicola

V. umbrinula Nyl.

V. viridula (Schrader) Ach.

[Description after British book, and others]: Thallus often extensive, gray-green to dirty white or greenish, or pale to dark brown or gray-brown, occasionally delimited by dark brown prothallus; areoles (0.2)0.4-1.0(-2.0) mm wide, angular, flat, smooth or uneven. Perithecia almost entirely immersed in areoles, with only the mouth showing (0.2 mm across); apex 0.3-0.5(-0.8) mm diam., flat to slightly convex; involucrellum "imperfect" (see Servit), excipulum brown-black; centrum 0.3-0.5(-0.7) mm diam., globose to broadly ellipsoid or flask-shaped. Spores 24-37 x 13-19 µm.

[Key after Clauzade & Roux]

1. Thallus very thick (0.5-2 mm), white to greenish gray or reddish gray; areoles coarse (0.5-2 mm), of "skvamet" aspect, often \pm lobed; medulla white to brown or black. Perithecia 0.4-0.5 mm diam., with involucrellum present only around the ostiole and excipulum \pm bottle-shaped, immersed or almost immersed, with black exciple and involucrellum. Spores 21-40 x 13-22 µm. V. obductilis (Nyl.) Zsch. (Syn.: V. viridula sensu Zsch.)

1. Thallus thin (< 0.5 mm), brownish (pale or somewhat greenish), sometimes

somewhat becoming green on account of "alvado", without black basal layer, rimose-areolate. Perithecia 0.2-0.4 mm, with involucrellum well developed, completely fused with the exciple, covering the upper 1/4, which projects above the rock. Spores 18-35 x 10-17 μ m. On calcareous rocks, walls and mortar. Colorado, Indiana. V. viridula

"V". zamenhofiana Clauz. & Roux

Thallus dark brown, subsquamulose; areoles finely crenulate-lobulate, densely aggregated. Spores broadly ellipsoid, 10-16 x 5.5-7.5 μ m. Parasitic on Staurothele areolata, eventually becoming independent. Colorado, Montana.

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etc., etc. (many other references consulted; much information yet to go into the key)