

**Rhizocarpon** Lam. ex DC.  
(LECANORALES: RHIZOCARPACEAE)

After various authors

Rev. 5/94

Thallus crustose (or absent in some species that are parasitic at least when young), when present usually truly areolate, more rarely partly immersed, continuous, rimose-cracked, warted, orbicular or spreading, sometimes somewhat effigurate at the margin, greenish yellow to yellow-green, white, gray, brown, or rust red, very rarely sorediate or isidiate; usually with a well developed black or rarely whitish to brownish gray, continuous or radiating hypothallus; attached to the substrate by prothallial hyphae; upper cortex usually well developed (thallus uniform and ecorticate according to Rogers); lower cortex absent. Medulla I-, K/I-, or + blue-violet. Medulla white or rarely yellow (rhizocarpic acid), of loose hyphae.

Apothecia immersed to sessile, attached to prothallus or on or at the edges of the areoles, or partly to entirely surrounded by rounded areoles (giving the impression of having a lecanorine margin), 0.2-0.5(-2) mm diam.; disk  $\pm$  round to angular, black,  $\pm$  concave to plane or weakly to strongly convex, smooth to minutely roughened or "sooty", epruinose; thalline margin absent true exciple black,  $\pm$  well developed, clearly evident when young, persistent or sometimes disappearing, of radiating hyphae, with a brownish or greenish black rim and usually a paler or rarely colorless inner part, frequently containing crystals; hypothecium medium to dark brown, lacking crystals, 30-55  $\mu$ m tall; hymenium hyaline to greenish, K/I+ blue; epihymenium red-brown to brown or green or blackish, frequently containing crystals or sometimes black granules, when red-brown often K+ red-violet; paraphysoids septate, 1.5-2.5  $\mu$ m thick, strongly confluent, richly branched and anastomosed, apical cell slightly to distinctly thickened; asci clavate or inflated-clavate or cylindrical, Rhizocarpon-type, unitunicate, I+; tholus well developed, I- in the lower part, I+ blue near the apex, lacking an ocular chamber; discharge fissitunicate; spores 8, less often 1-2 or variable in number,  $\pm$  ellipsoid (to irregular), 1-septate to submuriform or densely muriform, colorless to dark green or dark brown, usually with swollen perispore (mucilaginous halo) to 3-10  $\mu$ m thick, at least when young.

Pycnidia known for a few species only, simple or chambered, associated with the prothallus or immersed in the areoles; conidiogenous cells elongate, flask-shaped, pycnosporous cylindrical to acicular, straight or curved, borne terminally (exobasidial). Rhizocarpic acid (in the cortex of all yellow species); usually depsides or depsidones (stictic, psoromic, gyrophoric, barbatic, norstictic, lecanoric, physodic), or aliphatic substances in the medulla. Photobiont Trebouxia. Predominantly on hard, acidic, siliceous rocks; a few species parasitic or commensalistic on other crustose lichens on rocks. Arctic-alpine, to temperate.

Buellia species on rocks differ by their simple,  $\pm$  clavate paraphyses and generally smaller ascospores which lack a swollen perispore. Poeltinula cerebrina, which occurs on hard limestones, has 2-celled ascospores with a distinct perispore as in Rhizocarpon, but the apothecia are shortly lirelliform to angular with a thick, black, opaque exciple.

Rhizocarpon has been relatively well studied for a crustose genus, although the non-European, non-arctic species are mostly poorly known. Several of the most common and widespread

species complexes (R. geographicum, R. eupetraeum, and R. obscuratum) probably have to be lumped as single extremely variable species; my attempts to provide keys to the variations in latter two for the benefit of "splitters" are very preliminary, and should probably be ignored for the present.

**GROUP IA. Thallus ± yellow**  
**(uv+++ yellow, with rhizocarpic acid);**  
**spores 1-septate.**

Modified from Poelt (1988)

**1. Spores small, 9-18 µm long, brown with thin halo. Hymenium low, 50-100 µm, upper part dark reddish or more rarely dark greenish in KOH; with a black epithecium containing dark grains.** Tips of paraphyses rounded. Medulla I+ blue or I-. [Note: Catolechia wahlenbergii could also be keyed out here; it has thick, often wrinkled squamules, narrow at the base, black on underside; it grows on soil in north-facing cracks of acid rocks]. .....

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**1. Spores larger, 18-32 µm. Hymenium 100-150 µm; epithecium indistinct.**

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**2. Dark hypothecium completely separated from hypothallus and substrate by white medullary tissue.** Apothecia 0.6-2.0 mm diam., round or angular, higher than the areoles; disc plane to slightly convex, matt, minutely papillose-verrucose ("sooty"); margins thin, sometimes disappearing, the dark edge often partly eroding, exposing a paler inner part. Medulla white to yellowish white, K+ red (norstictic) or K+ yellow (stictic), I-. Exciple radiately structured, dark red-brown or violet-brown, K-. Paraphyses coherent, little branched; tips capitate. Thallus often fairly large, on black hypothallus, contiguous but usually separated by strips of hypothallus, or sometimes dispersed (ssp. boreale); areoles usually 0.5-1.5 mm diam. (to 2.5 mm in ssp. splendidum; to 3-6 mm according to Thomson), slightly concave to convex, angular, yellowish white to pure yellow (ssp. superficiale and boreale), or greenish yellow to brownish yellow (ssp. splendidum), matt or glossy to scabrous; surface coarsely verrucose at least when old (ssp. superficiale) or smooth (other ssp.); marginal areoles sometimes subradiate; areole margins sometimes slightly crenate. Spores 11-18 x 6 µm. On exposed rocks, usually very hard, acidic. Arctic-alpine, south to New Hampshire in the east and Colorado and California in the west. The K+ red strain was recognized by Thomson as R. crystalligerum. ..... R. superficiale

**2. Dark hypothecium at least in part reaching the hypothallus or substrate.** Thallus often smaller. Discs ± glossy, smooth. Medulla (in N. American species) K-. .... 3

**3. Areoles scattered on a dark prothallus.** Spores 9-14 x 5-7 µm. Medulla I+ blue, P-. Areoles 0.1-0.4 mm diam. Apothecia flat to strongly convex, with thin, distinct margin when young. Parasitic on Tremolecia atrata. May not be distinct from R. norvegicum. .... R. parvum

**3. Areoles contiguous to crowded. Prothallus absent or only slightly developed at thallus margin.** ..... 4

**4. Thallus of small (usually 0.2-0.5 cm diam.) dispersed groups of small (0.3-0.7 mm), usually strongly convex, bright yellow areoles.** Apothecia rounded and attached to areoles, 0.3-0.7 mm diam., convex, almost always immarginate. Prothallus lacking. Medulla I+ blue, P+ yellow (psoromic acid) or P-. On slightly calcareous or often heavy-

metal containing siliceous rock in places where there is little competition, especially on windswept ridges, arctic-alpine. .... R. norvegicum

**4. Thallus continuous; larger or parasitic.** P+ yellow (psoromic acid). ....

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**5. Medulla I-. Thallus margins not effigurate. Thallus parasitic, exclusively on Sporostatia spp.,** forming roundish islands to 1 cm broad; prothallus indistinct; areoles close together, 0.2-0.6 mm broad, flat to convex, angular or rounded-angular, whitish yellow to usually bright yellow, matt, smooth to slightly farinose. Prothallus developed only where parts of the thallus margin touch the rock. Apothecia 0.3-0.7 mm diam., angular, flat to convex, without distinct margin; exciple K+ violet; spores dark brown, constricted at center, 9-14(-16) x 7.5-9.5  $\mu$ m (4-6  $\mu$ m according to Thomson). Thallus C- (without gyrophoric). On hard, non-calcareous rock in exposed places, alpine. Alaska, Yukon. Perhaps a synonym of the species below. .... R. pusillum

**5. Medulla usually I+ blue-violet. Thallus margins often effigurate. Thallus not parasitic, or parasitic on lobate yellow Acarospora spp.,** usually ca. 1-2 cm diam.; areoles at margin usually elongate and radiate, commonly surrounded by black prothallus; areoles 0.3-0.8 mm diam., flat to strongly convex. Apothecia very angular, seldom attached to areoles. Spores 9-14 x 4-8  $\mu$ m. Thallus usually C+ rose (gyrophoric acid). On steep, exposed slopes of very hard rock, alpine. California, Colorado, Montana, Wyoming. .... R. effiguratum

**6. Epihymenium (upper hymenium) brown-red to red-violet in KOH. Medulla I-, K-, P+ yellow (psoromic), C- or sometimes C+ rose (traces of gyrophoric).** Thallus often large and widespreading, to more than 10 cm diam.; black hypothallus well developed; areoles to 1.5(-3) mm diam., to 1.5 mm thick, bright yellow-green, matt, usually crowded together, sometimes contiguous to widely scattered, usually secondarily cracked, round to angular or irregular, flat to moderately convex, smooth to rarely minutely scabrid, usually greenish yellow to whitish yellow. Apothecia to 1.5 mm diam., epruinose, usually roundish, often subdivided, flat to weakly convex; margin indistinct. Exciple K+ purplish red. Spores 18-32 x 9-15  $\mu$ m, sometimes with 1-2 additional, thin transverse septa. Morphology quite variable. On siliceous rocks in exposed situations (e.g., boulder fields), especially places with persistent snow cover, on level to sloping surfaces. Pacific NW, and New England. .... R. alpicola

**6. Epihymenium brownish-green to green in KOH. Medulla usually K+ red (norstictic).** Paraphyses clavate. Spores occasionally multicellular. .... 7

**7. Medulla I+ intense blue-violet or sometimes I- in part. Thallus  $\pm$  large and extensive,** on distinct black hypothallus, scattered or grouped; areoles to 1.5 mm diam., angular or rounded, slightly or very convex, whitish yellow or sometimes yellow or orange yellow, farinose to smooth. Apothecia to 1.5 mm diam., usually rounded, flat to slightly convex; margin black,  $\pm$  persistent; disc smooth to slightly rough, epruinose. Exciple K+ green but with red crystals; upper hymenium green to greenish blue, K+ green but with red crystals. Epithecium dark. Paraphyses tips clavate. Spores dark, 18-32 x 10-15  $\mu$ m. Medulla rarely K-, P+ yellow (psoromic acid) or K-, P- (bourgeanic acid). Thallus highly variable. An acidic or often slightly basic rocks, mostly on steep surfaces, arctic-alpine, Alaska, NW Territories, Maine. .... R. eupetraeoides

**7. Medulla I- or slightly bluish. Thallus to 5 cm wide but often smaller and sparsely developed,** on black hypothallus, dispersed; areoles to 1 mm, angular to rounded, usually slightly convex, whitish yellow to grayish yellow and often with a whitish pruina, rarely bluish green, matt. Usually K+, P+, sometimes with accessory psoromic or gyrophoric acids, rarely K-. Apothecia to 1 mm, rounded, very convex; margin persistent. Exciple K+ reddish. Hymenium K- or K+ green. Epithecium indistinct. Spores dark, 21-30 x 10-12 um. Mainly on basic rocks, arctic. .... R. inarense

**GROUP IB. Thallus yellow; spores 3-septate to muriform.**

Modified from Poelt, 1988

**1. Epithecium dark granular [?--R. viridiatrum lacks granules in apothecium according to Purvis, et al., but has them according to Thomson and according to Poelt]. Medulla I- or pale bluish.** Hypothallus (in N. American spp.) indistinct or completely lacking. Hypothecium brown, K-. Areoles 0.3-1.2 mm wide. Apothecia to 1 mm diameter. Predominantly species of dry, temperate to warm climates. .... 2

**1. Epithecium without blackish granules. Medulla I+ strong blue-violet.**  
..... 3

**2. At least young thalli parasitic on Aspicilia or Lecidea. Spores 15-28 x 7-14 um,** distinctly muriform, with 5-10 cells visible in optical section, dark brown. Medulla K-, P- (unknown fatty acids), or rarely K+ yellow, P+ orange (stictic), rarely C+ rose (gyrophoric acid). Hypothallus indistinct. Thallus to 2 cm diam., or sometimes much larger; areoles to 0.3-1(-1.2) mm diam., greenish yellow, matt, contiguous, flat to strongly convex, smooth, roundish to angular with irregularly crenate margins. Apothecia to 1 mm diam., epruinose, roundish, flat to usually strongly convex, often slightly elevated; margin usually soon disappearing. Exciple K+ faintly red; epithecium brownish black, K+ purple-red. Highly variable. On acidic to moderately basic basalts.

California. .... R. viridiatrum

**2. Not parasitic. Spores 35-50 x 15-20 um, 2 per ascus.** Hypothallus distinct or not. Medulla K+ red, P-. On basalt, especially in dry, lowland sagebrush-dominated areas, at least in the Pacific NW. .... R. cookeanum

**3. Ripe spores few septate, many or all only transversely or obliquely septate.** (also see Key I-A: R. eupetroides and R. inarense). .... 4

**3. Ripe spores muriform, with several longitudinal septa. R. geographicum complex** (very difficult; still being re-revised again). .... 6

**4. Hypothallus thin, black or lacking; areoles green or yellow; thallus small (ca. 0.5-2 cm). Apothecia usually distinctly marginate,** concave or flat, to 0.5 mm, rounded. Epihymenium indistinct. Hymenium hyaline or greenish, upper part brownish red. Spores dark, 12-21 x 6-10 um, 1-4-septate transversely, rarely becoming submuriform. Areoles contiguous to dispersed or usually clustered in groups, to 0.7 mm, irregularly angular,  $\pm$  convex, bright yellow to greenish yellow, matt or glossy. Medulla K-, P-, I- (according to Thomson, and according to Poelt) or sometimes P+ yellow, with psoromic acid (according to Purvis, et al.). On calcareous rocks (according to Thomson) or on exposed siliceous rocks (slightly calcareous or at least mineral-rich), when young sometimes parasitic on thalli of a wide variety of crustose lichens (e.g., Bellemerea), arctic-alpine, in open plant communities on windswept sites.

Alaska. .... R. intermediellum

**4. Hypothallus often thick, whitish or grayish; areoles whitish yellow; thallus usually large. Apothecia immarginate,** flat to concave, roundish, with thin margins. Areoles to ca. 1.5 mm diam., often divided. Epihymenium K+ red-violet. Spores 10-24

x 6-10 um, usually with 1-4 transverse and fairly often also a longitudinal septum, or divided evenly into four cells. It is doubtful whether the following division into taxa is warranted. .... 5

**5. Thallus P-, very thin, whitish to whitish yellow. Prothallus grayish. Medulla K-. .... R. atroflavescens ssp. atroflavescens**

**5. Thallus P+ yellow or P-, thickish, whitish yellow, often pruinose. Prothallus whitish. On calcareous rocks, alpine. .... R. atroflavescens ssp. pulverulentum (Schaerer) Runem.**

**6. Areoles mostly  $\pm$  crescent-shaped and partly to entirely surrounding the apothecia in a pseudolecanorine margin, or partly rounded without  $\pm$  central apothecium, rarely angular. Epihymenium K- or K+ greenish brown, rarely K+ brownish red and then main part of hymenium distinctly greenish. On siliceous rocks. .... 7**

**6. Areoles mostly not crescent shaped (except in "R. sphaerosporum" and so-called "unusual forms" of R. riparium, which may be fairly common!); areoles and apothecia often angular. Epihymenium various, sometimes K+ red with main part of hymenium hyaline. .... 8**

**7. Medulla K+ yellow, P+ reddish orange (stictic, often in low concentration). Areoles usually contiguous. Thallus to 4 cm diam., or merging to form extensive cover; hypothallus  $\pm$  distinct, black; areoles to 1.2(-1.5) mm diam., bright yellow to greenish yellow, matt, mostly distinctly convex. Prothallus conspicuous. Apothecia immersed, to 1 mm diam., epruinose,  $\pm$  round, flat to concave; proper margin persistent but usually rather indistinct. Exciple K- or K+ faintly red. Epihymenium pale olive brown, K- or K+ intensifying green. Spores (27-)30-38(-45) x 11-16(-19) um, with 14-28 cells in optical section, very dark greenish brown. Medulla I+ blue. In the open on upper surfaces of rock outcrops and boulders that are often impregnated with dust, often on rocks with considerable iron content. Arctic, and (according to Fink) "Throughout northern United States, and southward in the mountains". Common at least in parts of the western U.S., south to northern California; Ontario. .... R. lecanorinum**

**7. Medulla K-, P+ yellow (psoromic). Areoles often dispersed. Thallus pale yellow, mostly small. Spores 25-40 x 14-18 um, with 12-16 cells visible in optical section. On slightly calcareous or mineral-rich shales in competition-poor pioneer vegetation in places exposed to the wind. Alpine. .... R. ferax**

**8. Spores with more than 20 cells [check submature spores, which are still greenish and somewhat translucent]. R. macrosporum s. lato. .... 9**

**8. Spores with fewer than 20 cells. .... (see Key 1-B-1: R. geographicum s. lato).**

**9. Areoles 0.5-1.2 mm wide, thin, light yellow or grayish or greenish yellow, or bright yellow, not pruinose, angular to orbicular, contiguous to scattered; hypothallus often visible between the areoles, not pruinose. Apothecia generally angular, 0.3-0.7 mm diam. Four chemotypes: 1) barbatic acid, 2) psoromic acid, 3) stictic acid, 4) no medullary substances. On open, often dust-impregnated acidic boulders, lowlands in arctic-boreal areas, alpine in temperate areas. .... 10**

**9. Areoles usually 1-2 mm wide, thickish, bright yellow, usually faintly to distinctly pruinose, mainly angular and contiguous; hypothallus usually visible only at the periphery, ± pruinose. Apothecia generally roundish, to 1-1.5 mm diam.** Spores 32-70 x 16-25 µm. Areoles flat to very convex. Apothecia flat to concave. Medulla K-, P+ yellow (psoromic acid), rarely P-. Apothecial margin indistinct. No areoles collarlike. Epihymenium K+ red or K- to greenish brown. On ± calciferous rocks, montane in arctic-boreal areas. .... R. saanaense Räsänen (syn. R. sublucidum)

**10. Apothecial margin ± persistent. Thallus ± greyish or greenish. A few areoles collarlike. Thalli usually rather large.** Epihymenium K- or greenish brown. Medulla K+ yellow, P+ red (stictic acid) or P- (barbatic), rarely P+ (psoromic). Areoles thickish, not subdivided or barely so, to ca. 1.5 mm diam. Apothecia often sparse and dispersed, to ca. 1 mm diam., roundish. Spores 28-40 x 12-20 µm. Epihymenium K- or greenish brown. On large, dust-impregnated boulders and outcrops. .... R. sphaerosporum (= R. macrosporum according to Timdal, 1988)

**10. Apothecial margin indistinct. Thallus pale to bright yellow. No areoles collarlike. Thallus usually small.** Epihymenium K+ red or K- to greenish brown. Medulla P+ yellow (psoromic) or P-, rarely P+ brownish red (stictic). Spores 30-50 x 15-22 µm. .... R. macrosporum s. str.



### **I-B-1 (R. geographicum s. lato)**

Thallus to 15 cm diam.; hypothallus usually well developed, black; areoles 0.2-1.8(-2.5) mm wide, bright yellow green or more rarely greenish, grayish, or orange-yellow, matt or shiny, usually contiguous,  $\pm$  angular, flat to convex or rarely slightly concave, usually smooth. Medulla I+ blue. Apothecia to 1.5 mm diam., epruinose, round or angular, flat to slightly convex; margin thick to indistinct. Exciple usually K+ red; epithecium red-brown (K+ purplish red) or brown to olive-green (K- or  $\pm$  green intensifying). No crystals or granules in apothecium. Paraphyses tips clavate, hyaline or pale. Asci clavate. Spores (20)22-40(-46) x 10-19(-22)  $\mu$ m, muriform with 6-20(-24) cells in optical section, dark. Medulla P- or P $\pm$  orange-yellow, K-, c- or C $\pm$  red, containing either psoromic or barbatic acids, sometimes also  $\pm$  gyrophoric acid. Extremely common and variable; still poorly understood.

**1. Epihymenium (upper part of hymenium) brownish to dirty green, K- (section!), rarely K+ brownish red and then main part of hymenium distinctly greenish. Spores with 12-17 cells, 24-40 x 11-15  $\mu$ m, dark.** Thallus grayish green to greenish yellow (to bright yellow?), smooth, matt; areoles nearly continuous, angular or irregular, subdivided or not, flat; black hypothallus at margins, sometimes between areoles. Apothecia roundish to angular; margin thick or thin, persistent or not; discs flat to slightly concave, smooth. Exciple K+ brownish red. Hymenium 120-200  $\mu$ m. Paraphyses tips hyaline. Medulla P+ yellow (psoromic acid) or P-. On acid rocks, arctic-alpine, south to New York, New Hampshire, South Dakota, Arizona and California. R. riparium s. lato. (Lumped by Purvis, et al. under R. geographicum). ..... 2

**1. Epihymenium reddish, K+ more distinctly red (to red-violet); main part of hymenium hyaline. Spores with 6-10, less often 15 (rarely 20) cells, 20-32(-40) x 10-15(-16)  $\mu$ m.** Thallus usually large, bright yellow or  $\pm$  greenish yellow, rarely grayish yellow, smooth, matt or glossy; areoles contiguous or dispersed,  $\pm$  angular, flat to convex, strongly subdivided or not; black hypothallus present and sometimes conspicuous. Apothecia 0.3-1.5 mm diam., between the areoles, angular to rounded, flat; margin thin, distinct or not; disc smooth, epruinose. Hymenium 150-180  $\mu$ m. Medulla K-, P+ yellow (psoromic acid). On acid or calcareous rocks. Arctic-alpine, south to New Hampshire, New York, Minnesota, Colorado, and California. None of the infraspecific taxa described below (other than by implication the typical one) are listed by Egan, but several probably do occur in N. America. R. geographicum  $\pm$  s. str. .... 3

**2. Areoles strongly subdivided. Apothecia roundish, only the interior parts of the base filled with blackish tissue.** Medulla K-, P+ yellow (psoromic acid) or seldom P-; C-. ..... R. riparium ssp. riparium

**2. Areoles not strongly subdivided, flat, angular. Apothecia angular, their whole base filled with black tissue.** Medulla K-, P- (barbatic acid) or P+ yellow (psoromic acid), rarely C+ rose (gyrophoric acid). ..... R. riparium ssp. lindsayanum

**3. Spores with ca. 15 cells visible.** Apothecia 0.5-1 mm diam., distinctly marginate. Areoles 0.4-0.9 mm diam., angular, flat to convex, thick. Spores 28-40 x 12-16  $\mu$ m. On exposed outcrops and boulders, and in snowfields. .... R. geographicum ssp. diabasicum (Räsänen) Poelt & Vezda in Hawksworth, James & Coppins

**3. Spores usually with 6-10(-13) cells visible.** ..... 4

4. Apothecia roundish. Areoles strongly subdivided. .... 5
4. Apothecia angular. Areoles not strongly subdivided. .... 6
5. Areoles yellow to greenish, 0.4-0.9 mm diam., closely packed. Apothecia 0.4-1.5 mm diam. Spores 22-32 x 10-14 um. .... R. geographicum ssp. prospectans (Räsänen) D. Hawksw. & Sowter
5. Areoles whitish yellow, 0.4-1 mm diam., close together or often dispersed on black hypothallus. Spores 22-30 x 10-16 um. .... R. geographicum ssp. arcticum (Runem.) Hertel
6. Areoles about as thick as wide, usually bright yellow,  $\pm$  shiny. Apothecia with distinct margins. Apothecia numerous, 0.3-0.9 mm diam. Spores 20-32 x 10-14 um. Areoles 0.3-1 mm diam. On boulders and outcrops above tree limit, arctic-alpine. This is listed by Esslinger as a separate species, R. frigidum Räsänen. .... R. geographicum ssp. frigidum (Räsänen) Hertel
6. Areoles usually much wider than thick. Apothecia with indistinct margins. Apothecia 0.4-0.8 mm diam., angular. Spores 20-32 x 10-15 um. Areoles ca. 0.4-0.8 mm diam., often somewhat subdivided. Arctic-alpine to temperate and montane. .... R. geographicum ssp. geographicum

**GROUP IIA. Thallus brown/grey or whitish, UV-;  
spores 1-septate**

After Thomson (1967) and Poelt & Vezda (1981)

**1. Thallus of  $\pm$  distinctly umbilicate, concave (to flattish or convex) subsquamulose areoles,** red-brown, shiny, with thick, blackish grey, often pruinose margins, resembling apothecia; undersides dark. Spores 8 per ascus, 21-24 x 12-14  $\mu$ m, darkening. Black hypothallus present. Medulla I-; K-, C-, P- (barbatic acid), or sometimes K+ yellow, P+ orange (stictic acid). Apothecia round, convex; margin thin, subpersistent; disc becoming rugulose and convex, epruinose. Exciple black outside, paler to interior, K- or K+ violet. Epithecium brown; hymenium 100-140  $\mu$ m, hyaline; paraphyses coherent; tips clavate. On acid rocks, arctic (Alaska to Greenland). ..... R. rittokense

**1. Thallus areoles not umbilicate or subsquamulose. .... 2**

**2a Thallus chalky white,** thick, subfarinose, rimose-areolate, forming small orbicular patches; blue-black hypothallus often present at periphery. Medulla I-, K-, C-, P-. (If thallus UV+ yellow see Group IA--R. eupetraeoides and R. inarense). Apothecia  $\pm$  immersed, with a pruinose false-thalloid margin around the proper margin, sessile to raised; disc plane to slightly convex, smooth, sometimes pruinose; proper margin thin, pruinose, disappearing. Epithecium brown-violet or purplish black, K+ red-purple. Exciple black or purplish black. Hymenium 100-125  $\mu$ m, violet red above; paraphyses thin, capitate. Spores often aborting, 12-16(23) x 6-10(12)  $\mu$ m, hyaline but usually eventually darkening, constricted. Apothecium with stictic acid. On calcareous rocks. Arctic. .... R. chioneum

**2b Thallus gray to brown. .... 3**

**3. Thallus with cephalodia.** Thallus with pink to brown tones (reddish brown, light orange, grayish reddish orange or yellowish pink to dark reddish gray), rimose-areolate, continuous, sometimes smooth at edges; prothallus basent or black and conspicuous. Cephalodia cushion- or disk-shaped, greenish brown when wet and black or dark brown when dry, containing Stigonema. Apothecia adnate to slightly immersed, 1.0-1.5(-3.0) mm diam., epruinose; margins black, at first even with disc, later thin, slightly raised, persistent. Hymenium 150-200  $\mu$ m; epihymenium brown, K-, not granular. Spores 30-35-38(-46) x 14.2-17.2-20.0  $\mu$ m, 8 per ascus. Medulla K+ yellow, P+ orange, C-, I-, containing stictic acid and almost always menegazzic acid in varying concentrations. On siliceous rocks, close to shore on bluffs, and in alpine zone, British Columbia; Alaska. .... R. hensseniae

**3. Thallus without cephalodia. .... 4**

**4. Spores remaining hyaline or only finally darkening. .... 5**

**4. Spores soon darkening. .... 9**

**5. Medulla I+ blue-violet,** K-, C-, KC-, P-, or rarely K+ yellow, P+ orange (stictic). Thallus on black hypothallus; areoles to 0.8 mm broad, usually contiguous and angular, sometimes crescent-shaped around the apothecia, pale to dark brownish, gray or gray brown. Apothecia to 0.8 mm diam., slightly constricted at base; discs flat to concave, matt or glossy, sometimes brown;

margin thin to usually moderately thick, persistent. Epithecium brown or violet-brown, lacking crystals, K+ very red or red-violet, sometimes K-, but never K+ greenish; hymenium 110-130 um, hyaline or faint greenish blue above. Spores 17-30 x 7-14 um, rarely 3-septate. On acid rocks, arctic-alpine, inland. Alaska. .... R. polycarpum

**5. Medulla I-.** ..... 6

**6. Medulla and exciple K+ red, P+ yellow or orange (norstictic).** Thallus on well developed black hypothallus,  $\pm$  orbicular; areoles pale to medium gray, often with a brown or mauve-gray tinge, matt, contiguous or  $\pm$  scattered, verrucose, rounded, moderately to strongly convex. Apothecia mostly immersed, 0.2-0.5(-1) mm diam., often contiguous, epruinose, round to somewhat angular, persistently flat to slightly convex; margin persistent, thin. Exciple brownish black in the rim, inner part paler brown, containing crystals dissolving in K. Hypothecium red-brown; epithecium greenish (or red-brown?), K+ intensifying green or K-; spores (13.5-)15-18(-24) x (6-)7-9(-12) um. On rock, around edges of late snow patches. Minnesota, Ontario. .... R. cinereovirens

**6. Medulla K- (no norstictic); exciple K- or K+ violet.** ..... 7

**7. Apothecia flat with persistent margin. Thallus  $\pm$  brownish.** ..... 8

**7. Apothecia becoming convex and immarginate. Thallus whitish-gray or bluish-gray.** Thallus to 5 cm diam., rimose to areolate; prothallus usually distinct, black; areoles to 0.5 mm diam., matt, contiguous or often scattered,  $\pm$  angular, flat. Apothecia to 1 mm diam., black, not pruinose, rounded; proper margin narrow; exciple paler brown inside, K-; epihymenium bright green to blue-black, K-; paraphyses with a sharply delimited, green-pigmented cap; hymenium colorless. No crystals or granules in apothecium. Spores 14-17 x 6-9 um. No substances. .... R. expallescens

**8. Thallus grey-brown.** Spores 15-20 x 8.5(10.5) um. Apothecia 0.3-0.5 mm diameter. .... R. polycarpoides

**8. Thallus ashy, bluish-ashy, reddish-ashy or ochraceous,** very thin, uniform, subcontinuous to chinky-areolate, rarely verrucose to dispersed or lacking, sometimes slightly pruinose, esorediate; black hypothallus sometimes present. Medulla usually K-, C-, KC-, P-, I-, rarely K+ yellow, P+ yellow (stictic acid). Apothecia sessile, 0.5-1(-1.2) mm, black, slightly higher than thallus; disc epruinose, flat, smooth; margin thin, persistent; epithecium bluish black or olivaceous brown; exciple reddish brown, radiate; hymenium 100-110 um, upper part bluish or olivaceous, K-; paraphyses slightly capitate. Spores (11-)13-24(-29)(-36?) x (7-)9-12(-15) um. On acid rocks, especially in moist or periodically irrigated sites, sometimes in woodlands, arctic to boreal. Ontario (and elsewhere). .... R. hochstetteri

**9. Medulla I+ blue-violet, K+ yellow or K-, C-.** Thallus grey-brown to dark brown, rimose-areolate, to 5 cm diam.; black hypothallus well developed; areoles to 0.3 mm diam., matt, contiguous or scattered, rounded to angular, flat. Apothecia to 0.8 mm diam., epruinose, orbicular or angular to slightly flexuose,  $\pm$  flat; margin narrow and persistent. Exciple and hypothecium K $\pm$  diffusing pruplish red; epithecium brownish black, K- or K+ faintly red; spores 11-15 x 5-7 um. On sunny, acid,  $\pm$  vertical rock faces. .... R. simillium

**9. Medulla I-, C-, K+ or K-, P+ or P-. . . . . 10**

**10. Medulla K+ red or yellow, P+ orange (stictic or norstictic acids). . . . . 11**

**10. Medulla K-, P-. . . . . 13**

**11. Epithecium red-brown to dark brown, K+ red, not containing crystals; exciple K-; spores 25-35 x 14-17 um. Medulla K+ yellow (stictic). Thallus grey to grey-red, bullate-areolate or areolate. Very similar to "R. badioatrum sp. 2", but areoles more plane, more contiguous, angular or often slightly crenulate, containing stictic acid. [an apparently rare strain of R. badioatrum also keys out here]. . . . . R. cinereonigrum**

**11. Epithecium green to brown-black, K- or intensifying green, containing crystals refracting polarized light and dissolving in K. . . . . 12**

**12. Areoles to 1.5 mm diam., dark brown and usually faintly gray pruinose, matt, plane to weakly convex, usually contiguous. Medulla K+ yellow (stictic). exciple K+ violet above or K-; spores 25-35 x 12-17 um. Thallus to 10 cm diam.; black prothallus well developed; areoles irregularly rounded or angular, flat to weakly convex. Apothecia to 1.5 mm diam, epruinose, round, remaining ± flat; proper margin thick, persistent. On siliceous rocks. . . . . R. jemtlandicum**

**12. Areoles to 1 mm diam., pale gray to dark gray or dark brown, matt or shiny, plane to bullate, scattered or contiguous. Medulla K+ yellow (stictic) or K+ red (norstictic). Thallus on black hypothallus, ashy gray, usually slightly shiny; areoles verrucose or smooth. Apothecia between the areoles, flat to convex; margin thin to thick, persistent; discs epruinose, slightly roughened, matt or shiny. Epithecium green-black, K-; exciple K+ red with needle-like crystals. Hymenium 140 um, greenish above; paraphyses tips dark, capitate. Spores 21-30 x 9-12 um, bluish black. On acid rocks, arctic, from Ellesmere Island to Alaska, south to Labrador, Manitoba and Saskatchewan. . . . . R. copelandii**

**13. Thallus strongly brown, ± shiny, appearing black; areoles brown, flat, often with depressions, at the edge of thallus often scattered on dark prothallus. Apothecia to 1 mm, finally convex and immarginate. Exciple sordid yellow inside. Epihymenium blue-green. Spores 17-21 x 9-11 um. Medulla I-. Greenland; Alaska. . . . . R. praeabadium (Nyl.) Zahlbr.**

**13. Thallus not shiny, gray to brown, not appearing black. . . . . 14**

**14. Thallus grey to brown, dark brown, red-brown, olivaceous, or ashy, little pruinose, areolate to bullate-areolate or verrucose, esorediate; areoles flat to convex, contiguous to dispersed, round or angular, smooth; black hypothallus prominent. Medulla K-, C-, I-. Apothecia dispersed or aggregated, round or rounded-angular; margin thin and persistent or disappearing; disc flat, epruinose, papillate. Epithecium red-brown, K+ red-violet, without crystals; exciple K+ slightly yellow; spores 22-28 x 12-16 um, soon brown, constricted. Hymenium 130 um, reddish above; paraphyses capitate; asci saccate. On acid rocks in open situations, arctic to temperate, Baffin Island to Alaska, south to New Hampshire, Minnesota, and Colorado. Timdal (1988) accepts two distinct taxa (treated by Poelt & Vezda, 1981 as var. badioatrum and var. vulgare) under this name**

from Scandinavia; both may also be present in N. America. .... 15

**14. Thallus ochraceous**, areolate. Epithecium blue-black; exciple K<sup>+</sup> violet. Spores 12-15 x 7-7.5  $\mu$ m. .... R. alaxense

**15. Areoles thick, contiguous, plane, angular to crenulate. Medulla lacking lichen substances.** In lowlands and mountains, from dry boulders in pine forests to periodically inundated rocks in rivers. .... "R. badioatrum sp. 1"

**15. Areoles medium thick,  $\pm$  scattered, usually convex to hemispherical,  $\pm$  orbicular. Medulla containing diffractaic acid.** More restricted to dry boulders, apparently not above timberline. .... "R. badioatrum sp. 2"

**GROUP IIB. Thallus grey/brown to whitish, UV-  
spores 3-septate to muriform.**

After Feuerer (1991), Thomson (1967), and Poelt & Vezda (1981)

**1. On soil.** Spores 3-5-septate transversely to submuriform, 1-3-septate longitudinally, 22-38 x 10-18  $\mu$ m. Thallus dirty whitish to ochraceous-yellowish, continuous to indistinctly rimose or minutely granulate, gelatinous when moist, composed of loosely interwoven hyphae, K-, C-.

Apothecia 0.4-1.5 mm diam., partly immersed to adnate, flat to slightly convex, dull black; margin thin, black, obscurely crenulate, finally disappearing; spores 4-6 per ascus, ovoid, hyaline to brown. Mountains of southern California. .... R. athalloides

**1. On rock.** ..... 2

**2. Thallus white (chalky, creamy, or bluish) to pale gray, thin, continuous.**

**Apothecia pruinose; margin thick. Epithecium blue-black or olive-black. Thallus continuous.  $\pm$  Calicicolous.** (If on acidic rock, see R. obscuratum and R. plicatile). ..... 3

**2. Thallus brown or gray, sometimes fading to creamy when old. Silicolous.**

**Apothecia not pruinose. Exciple dark.** ..... 5

**3. Paraphyses branched and anastomosing; tips not swollen or dark-capped. Apothecia flat, not in botryose clusters;** excipulum pale inside, occasionally with algae. Epihymenium  $\pm$  olive, with crystals dissolving in K (crystals K+ yellow or orange). Medulla usually K+ yellow, P+ yellow to orange (stictic acid). ..... 4

**3. Paraphyses simple; tips swollen with dark caps. Apothecia in convex botryose clusters; margin pruinose or not. Spores 12-14 x 5.5-7.7  $\mu$ m.** Alaska. .... "R. cumulatum" (= Buellia sp. related to B. epipolia, according to Feuerer, 1991; B. epipolia is treated by other authors in the genus Diplotomma)

**4. Spores 18-24-30 x 10-14-16  $\mu$ m. Apothecia little to distinctly projecting above thallus,** to 1.5-2 mm wide; disc rarely also pruinose; margin thick to very thick, usually persistent, distinctly pruinose. Thallus to 5 cm diam., continuous or partly rimose, white, matt, pruinose; prothallus usually poorly developed, black, white-pruinose. On calcareous rocks, especially hard limestones, in relatively moist and cool sites. Arctic-alpine, NW Territories to Alaska. .... R. umbilicatum

**4. Spores 20-40-50 x 13-18-24  $\mu$ m. Apothecia mostly evenly high with thallus, rarely projecting above it;** often in concentric rings, but often also irregularly distributed; margin mostly persistent; hymenium 100-120-140  $\mu$ m (???--according to Feuerer's description; 150-170-190  $\mu$ m according to his key, but this seems unlikely as his descriptions states that the asci are only 80-110  $\mu$ m tall!). Apothecia flat, rounded, 0.5-0.7-0.9 mm diam. (to 1.8 mm according to ?), proper margin persistent. Thallus thin, rimose-areolate; hypothallus poorly developed; areoles 0.5-0.8-1.2 mm diam. (to 0.5 mm according to Purvis, et al.), matt, contiguous, mainly angular, flat. Exciple pale inside. On  $\pm$  basic rocks and walls and especially on hard acid rocks often in close proximity to basic rocks or mortar, usually on calcium-containing silicates, mostly in lower or warmer sites. Reported from N. America by Feuerer, 1991, but no specimens from the continent

cited by him. Reported by Fink (as R. petraeum) from "throughout northern United States, and southward in the mountains"; including var. confervoides (DC.) Zahlbr., with minutely to coarsely granulose thallus, from Vermont, and from Alabama and Minnesota (as R. concentricum). (Purvis, et al., 1991 accept R. concentricum ("Davies") Bletr. as a good species, do not mention R. petraeum, and list R. perlutum as a synonym; Feuerer, 1991 treats R. perlutum as a synonym of R. lavatum but treats R. concentricum "auct." as a synonym of R. petraeum; his description of R. petraeum closely matches that of R. concentricum except for the difference in areole size. .... R. petraeum (syn.: R. concentricum auct. [non (Davies) Bletr.?!])

**5. Spores remaining pale (or only slightly dark when overripe).** ..... 6

**5. Spores soon dark.** (This choice often difficult!). ..... 13

**6. Spores when ripe 3-septate, without longitudinal septa.** Thallus gray, warty-areolate, on black prothallus. Medulla I-. Spores  $\pm$  muriform, colorless, 18-24 x 8-11  $\mu$ m. Hymenium ca. 120  $\mu$ m high. Apothecia ca. 1 mm wide, flat with thick persistent margins. Alaska. .... R. anseris Lynge

**6. Spores in the ripe condition weakly to strongly muriform, with at least one longitudinal septum, or if spores mainly 3-septate (R. oederi) then thallus ochraceous to rusty.** ..... 7

**7. Number of spores per ascus varying from 1 to 8, most often 2 or 4. Thallus dark brown, rimose-areolate,** matt, to 10 cm diam.; hypothallus well developed, black; areoles to 1 mm diam., scattered to contiguous,  $\pm$  rounded and flat. Apothecia 0.3-0.5(-1) mm, without false-thalloid margin, epruinose,  $\pm$  rounded, flat to weakly convex; margin persistent. Epithecium olive-green, K+ intensifying green. Spores 25-50 x 19-23(-28)  $\mu$ m. Thallus K+ yellow or red, P+ orange, or K-, P-. Four chemotypes: 1) stictic, 2) norstictic, 3) barbatic, 4) no substances. On  $\pm$  nutrient-rich, siliceous rocks. Minnesota. .... R. subgeminatum

**7. Number of spores per ascus  $\pm$  constant, overwhelmingly 8. Thallus grayish to pale brown or ochraceous-rusty, or if dark brown (R. bolanderi) then thallus of peltate areoles, not rimose-areolate.** ..... 8

**8. Thallus ochraceous to orange-brown or rust-colored,** matt, to 5 cm diam. but often coalescing; areoles 0.2-0.5-0.7 mm across, contiguous, usually angular, flat to  $\pm$  convex; prothallus indistinct. Apothecia to 0.5 mm diam., epruinose, angular to flexuous, flat; disc usually umbonate or sub-gyrose (with rings of sterile tissue), often papillose or uneven; margin distinct. Exciple K-; epithecium in section brown-black, olive or greenish black to blue-black, K-. Paraphyses tips fusing into a pseudoparenchymatous tissue. No crystals in the apothecia; no substances. Spores 12-15-18(-21) x 3-5-7(-9)  $\mu$ m, mainly 3-septate (to weakly muriform). Medulla I+ blue. No substances. On siliceous rocks rich in iron minerals. At high elevations, Maine, New Hampshire, Oregon, California; Ontario. No specimens from the continent cited by Feuerer, 1991. .... R. oederi

**8. Thallus grey, brownish, or whitish (or sometimes rusty in R. lavatum).** ..... 9



**9. Epihymenium carbonaceous incrusted, in section brown-black, opaque. Medulla I+ blue, K+ yellow, P+ yellow (stictic acid). Thallus grey-brown to brown or occasionally red-brown; areoles flat to weakly convex, usually contiguous, mainly angular, 0.2-0.4-0.5 mm diam. Apothecia 0.3-0.6-1.0 mm diam., at thallus level,  $\pm$  immarginate or with thin persistent margin, epruinose, round to angular, remaining  $\pm$  flat. Exciple K+ red. Epithecium K+ yellow or K- (K+ violet according to ?). Spores 3-septate to submuriform, 24-32 x 11-15  $\mu$ m, sometimes greenish brownish with age. On siliceous rocks and walls, in low, moist and cool places. Greenland and widespread in Europe; no specimens from U.S. or Canada cited by Feuerer. .... R. distinctum**

**9. Epihymenium in section pale brown, pale gray to olive-brown or blue-black, rarely almost colorless; often dark through over-aging; paraphyses tips somewhat branching, not fusing into a pseudoparenchymatous tissue. Medulla I-. .... 10**

**10. Spores 13-16 x 8-9  $\mu$ m, few-celled, submuriform. Epihymenium blue-black. Areoles 0.4 mm wide, flat. Apothecia 0.4-0.7 mm, convex, scabrid. Hypothecium brown-red, K+ violet. .... R. microsporum**

**10. Spores over 16  $\mu$ m long (often at least partly over 24  $\mu$ m long), 3-septate to strongly muriform. Epihymenium (in most species?) olive to red-brown. .... 11**

**11. Medulla K+ red, P+ yellow or orange (norstictic). Thallus whitish to grey-green. With crystals in exciple and epihymenium, soluble in K. Thallus to 5 cm diam.; prothallus rather indistinct, black; areoles to 0.5 mm diam., gray to pale brown, matt,  $\pm$  contiguous, rounded to angular, moderately strongly convex or becoming warted. Apothecia sessile, to 0.8 mm diam., epruinose, round, flat to slightly convex; margin thick, prominent, persistent. Exciple K-; epihymenium K-. Spores (20-)24-32 x (8.5-)10-14(-16)  $\mu$ m, strongly muriform. On hard acid rocks and pebbles. Ontario. .... R. plicatile**

**11. Medulla K+ yellow (stictic acid) or K-. Thallus mostly brownish gray, sometimes whitish, but not greenish. .... 12**

**12. Epihymenium with crystals dissolving in K (K+ yellow or orange). Proper margin  $\pm$  pruinose; apothecia at least when young with wide false-thalloid margin. Thallus white to medium grey. Medulla and exciple usually K+ yellow, P+ yellow (stictic acid), rarely K-, P-. .... (see R. petraeum)**

**12. Epihymenium usually not containing crystals. Proper margin not pruinose; apothecia without false-thalloid margin. Thallus medium gray, pale brown, or dark brown or ochraceous, K-, or sometimes K+ in R. obscuratum. .... 13**

**13. Thallus pale gray, brown or red-brown, usually partly ochraceous or sometimes rusty. Spores (23-)30-36-42 x (10-)14-16-18  $\mu$ m, with very numerous cells. Hymenium 120-160-200  $\mu$ m high. Apothecia mostly over 0.8 mm diam. Proper exciple thick, persistent,  $\pm$  tumid; disc smooth or slightly roughened. Thallus rimose to areolate, areoles flat, 0.3-0.5-0.7(-1) mm diam.; prothallus indistinct. Apothecia relatively low (ca. 0.2 mm thick), 0.8-1.2-1.6 mm diam., mostly "überragend" (surpassing, towering above) the areoles in a characteristic manner (immersed between areoles according to Wong & Brodo 1992),  $\pm$  flat, sometimes umbonate epruinose, round; margin thick, persistent, often paler than disc. Exciple K-; epithecium olivaceous, K-. Thallus K- (no substances in TLC). Apothecium without crystals. Spores usually with 5-7(-9) transverse septa and 1-2 longitudinal septa. On siliceous rocks subjected to**

inundation. Ontario. Reported from N. America, but N. no American specimens were cited by Feuerer. .... R. lavatum

**13. Thallus brown-grey to grey, dark gray or dark brown, or sometimes whitish. Spores 20-28-33(-36) x 9-13-16 um, with few to moderately numerous cells. Hymenium 70-100-130 um. Apothecia mostly to 0.6 mm diam. Proper exciple thick or more often thin or disappearing; disc ± roughened.** Thallus to 10 cm diam., warty-rimose to areolate; areoles 0.2-0.3-0.5(-1.0) mm diam., flat to weakly or highly convex, matt, angular to ± round; prothallus usually distinct, black, sometimes fimbriate. Apothecia not much projecting above thallus, 0.2-0.4-0.6(-1.0) mm diam., mostly flat, rarely convex; round, epruinose or rarely ± ochraceous pruinose, Lecidea-like; disc often ± umbonate roughened; proper margin thick, persistent, black or appearing pseudolecanorine. Thallus K+ yellow (stictic acid?) or K+ red (norstictic acid?), or K-, P-, C- (no substances). Exciple K-; epithecium red-brown or olivaceous, K-. No crystals in apothecium. Spores with 3-4 transverse septa and 1 longitudinal septum. On smooth, dry, siliceous rocks. New England (Maine) to Tennessee, Virginia, Indiana, Alabama; Washington; Ontario, Quebec, Newfoundland; Greenland. Relatively shade tolerant. Extremely variable. .... R. obscuratum

**14. Parasitic on Dimelaena oreina.** Thallus to 2 cm diam., occasionally the inner areoles falling out; areoles high-convex, ± bluish to dark grey. Medulla K-, C-, I+ blue-violet. Paraphyses capitate. Epithecium C-, K+ red or K-. Spores 16-24-32 x 9-12-16 um, many-celled, brown-black, almost opaque. Very similar to R. eupetraeum except for parasitic habit. Colorado; Greenland. .... R. renneri

**14. Not parasitic.** ..... 15

**15. Spores 1 or 2 per ascus.** Areoles umbilicate or not. Medulla I-. .... 16

**15. Spores (4-)8 per ascus.** Areoles not umbilicate. Medulla I+ blue-violet or I-. .... 18

**16. Areoles very strongly peltate (umbilicate), concave to flat, brown to red-brown or dark brown, shiny, with thick, incurved, sinuate, usually dark or ashy-colored margins.** Apothecia 0.3-0.4-0.6 mm diam. Epihymenium in section brown to brown-black; paraphyses tips fused into a pseudoparenchymatous tissue. Spores overwhelmingly 2/ascus, 3-septate to usually muriform with very numerous cells, 34-48-68 x 18-26-32 um, dark brown to olive brown. Superficially very similar to some brown Lecidea species, but areoles usually smaller, more concave, darker, and shinier. Medulla sometimes bright yellow (and often exposed), in v. sulphurosum (Tuck.) Zahlbr. On siliceous rocks, western U.S. (southern California to Washington), ca. 500-2300 m, very common at least in the Sierra Nevadas. Also reported from western Greenland. .... R. bolanderi

**16. Areoles not umbilicate, flat to warty convex or almost globose, mostly gray to gray-brown, rarely distinctly brown (mostly due to abrasion or injury), matt, without differentiated margins,** with to 10 um thick epinecral layer. Apothecia convex. Epihymenium red-brown to brown-black, partly fused into a pseudoparenchymatous tissue, K+ red. The following choice is admittedly a strange one. .... 17

**17. Spores 1 per ascus. Thallus usually P-, K+ weakly yellow, rarely K+ strong yellow, rarely K-, P+ reddish, without yellow medulla.** Spores 48-60-78 x 18-26-33 um. Areoles 0.2-0.5-1.0

mm diam. Apothecia 0.4-0.6-0.9 mm wide; margin thin or mostly absent. In semi-arid regions, arctic to temperate. Colorado, S. Dakota, Arizona, Minnesota; Greenland. .... R. disporum

**17. Spores 2 per ascus, or rarely 1 in occasional asci. Thallus usually P+ yellow to red, K+ weak yellow (stictic acid) or occasionally K+ red (norstictic acid), rarely K-, P- (rhizocarpic acid in medulla only, giving medulla lemon yellow color). Spores 45-53-68 x 18-24-28  $\mu$ m. Areoles 0.3-0.5-0.8 mm diam. Apothecia 0.4-0.6-0.8 mm wide; margin at first  $\pm$  thick, then mostly absent; marginless apothecia present between the areoles. Chemotype with yellow, K-, P- medulla usually has dark brown, small, plane, angular areoles and is restricted to  $\pm$  calciferous rocks in the lowlands; it may represent a distinct taxon. In cold and wet regions. Alaska; California; NW Territories; Ontario, Greenland. .... R. geminatum**

**18. Thallus minutely granulose, straw-colored. Spores 3-septate, 14-18 x 5-7  $\mu$ m, oblong-ellipsoid, slightly constricted at septa, brown. Thallus thin; granules convex, scattered or clustered, covering small areas and usually resting upon and bordered wholly or in part by a black hypothallus. Apothecia 0.2-0.6 mm diam., partly immersed to adnate, flat to convex, black; margin thin, prominent, black, finally disappearing. On rocks, Ohio. .... R. vermicoides**

**18. Thallus areolate, usually grey, rarely gray-brown, or pale brown to brown where abraded, Spores muriform, many-celled, 22-36-42 x 10-16-18  $\mu$ m, brown to brown-black. Thallus 2-6 cm diam.; areoles mostly close together forming a continuous thallus, rarely scattered on strongly developed prothallus; areoles peltate, mostly 0.3-0.8-1.4 mm wide, 0.4-0.6-0.8 mm thick, almost always strongly to very strongly convex; surface smooth, matt. Apothecia 0.3-0.8-0.9 mm diam., mostly flat with thin margin to convex-immarginate. Hymenium 100-120-140(-160)  $\mu$ m high. Epihymenium brown to brown-black, K+ strong red or sometimes K-; paraphyses tips fused into a pseudoparenchymatous tissue. Spores dark. In somewhat dry sites. Very variable. (If areoles concave to flat and spores 4(-5) per ascus, and growing in Greenland, see R. arctogenum—description in Thomson 1997) (If spores 3-septate to submuriform and rather pale, see R. obscuratum). On acid rocks, arctic-alpine to temperate, south to Vermont, New York, Wisconsin, Minnesota, Tennessee, Michigan, South Dakota, Wyoming, Colorado, Idaho, and California; Newfoundland; Labrador; Greenland. .... R. eupetraeum s. lato.**

## Key to R. obscuratum s. lato

Modified after Timdal, 1988 and Fink, 1935

**1. Spores truly muriform, [mostly?] 3-7-septate transversely and 1-3-septate longitudinally, at least partly over 25 µm long. Epihymenium [usually?] not containing crystals, [sometimes?] greenish. Thallus [usually?] K-(no lichen substances). .... 2**

**1. Spores 3-septate to submuriform, or if muriform (R. albineum), under 25 µm long. Epihymenium [usually] containing crystals dissolving in K, [usually?] pale brown, red-brown, or brown-black. Thallus [usually?] K+ yellow, P+ orange (stictic acid). .... 4**

**2. Thallus poorly developed or partly endolithic, olive to black, verrucose;** hypothallus indistinct; verrucae 0.1 mm. Spores 20-34 x 10-18 µm. Apothecia to 0.4 mm, flat, margin persistent. Epithecium dark green. No substances. .... R. anaperum (= R. obscuratum according to Feuerer, 1991, but kept separate by Esslinger & Egan)

**2. Thallus grayish brown, ashy or gray, minutely granulose, thin, the granules flat,** continuous or rarely scattered. Spores oblong-ellipsoid, 3-7-septate transversely and 1-3-septate longitudinally. Apothecia partly immersed to adnate, flat; margin ± thick. .... 3

**3. Apothecia 0.2-0.5 mm across, numerous, sometimes crowded; spores 20-36 x 8-14 µm,** hyaline to rarely brownish. Thallus ashy to gray. Chem.? Tennessee. .... R. interponens (= R. obscuratum according to Feuerer, 1991)

**3. Apothecia 0.2-0.8 mm diam. Spores 20-32(-46) x 9-15(-18) µm,** hyaline to brownish. Thallus grayish brown to ashy or medium gray to dark brown, well developed; hypothallus black, well developed. No substances. Maine and Minnesota. .... R. obscuratum s. str.

**4. Spores remaining 3-septate.** Apothecia 0.5-0.8 mm diameter, never gyrose. Thallus of scattered warts, dark brown. Spores 14-22 x 7-9 µm. Medulla KI- or KI+ faintly blue. Ontario. .... R. submodestum (= R. obscuratum according to Feuerer; R. submodestum accepted as a separate species by Esslinger & Egan)

**4. Spores muriform or submuriform. .... 5**

**5. Spores 21-26 x 10-15 µm, 3-7-septate transversely and 1-2-septate longitudinally.** Thallus whitish to ashy, moderately thick, rimose-areolate; areoles flat, rather large, commonly in dense groups on a black hypothallus. Apothecia 0.35-1 mm across, partly immersed to adnate, flat to convex; margin thin or disappearing. Spores hyaline to dark brown, oblong-ellipsoid. New England to Virginia, and Indiana. .... R. albineum (= R. obscuratum according to Feuerer, 1991)

**5. Spores mostly under 20 µm long, or if larger then few-celled, submuriform.** Epihymenium containing crystals dissolving in K. Medulla K+ yellow (stictic acid). .... 6

**6. Spores 15-20 x 10-12 µm, submuriform. Epithecium red-brown.** .... R. permodestum (= R. obscuratum according to Feuerer, 1991)

**6. "Not as above" [more info. needed, especially on R. permodestum]. .... 7**

**7. Rim of exciple reddish brown, K+ red. Spores 17-25 x 9-13 um.** Thallus whitish. Epithecium pale brown to brown-black. Apothecia  $\pm$  flat. .... R. subpostumum (= R. obscuratum according to Feuerer, 1991)

**7. Rim of exciple greenish black, K-. Spores 15-21 x 8-11 um.** ..... 8

**8. Areoles thin or partly endolithic, pale brown; hypothallus indistinct.** Spores ellipsoid to fusiform-ellipsoid, hyaline to brown, 3-septate transversely and becoming 1-septate longitudinally, 12-18 x 5-8.5 um. Thallus thin, ashy to grayish brown, becoming minutely granulose or warty, sometimes disappearing. Apothecia 0.2-0.6 mm across, adnate, flat to convex; margin thin, finally disappearing. Alabama. .... R. postumum (= R. obscuratum according to Feuerer, 1991; accepted as a separate species by Esslinger & Egan)

**8. Areoles rather well developed, medium gray to dark brown; hypothallus thin, black.** .... R. tetramerum (= R. submodestum according to Poelt & Vezda's second supplement; synonymized under R. obscuratum by Feuerer 1991; accepted as a separate species by Esslinger & Egan; according to Poelt's original Bestimmungsschlüssel, R. tetramerum has apothecia 0.2-0.3 mm diam. and R. submodestum has apothecia 0.5-0.8 mm diam.; both have 3-septate, non-muriform spores)

ADD:

Spores few-celled, to 20 um long. .... R. reductum (= R. obscuratum according to Feuerer, 1991)

## Key to R. eupetraeum s. lato

- 1. Medulla I+ blue. .... 2
- 1. Medulla I-. .... 3

### 2. Medulla C-, KC-, K+ yellow or red, P+ orange (stictic or norstictic), or K-.

Thallus grey to gray-brown or brown, or sometimes whitish; areoles verruculose, often very highly convex, rounded. Spores 3-4-septate transversely, 1-2-septate longitudinally. Apothecia between the verrucules, round, flat; margins thin, persistent or not; disc flat, smooth. Exciple radiate. On acid rocks, arctic-alpine, south to Vermont, New York, Wisconsin, Minnesota and Idaho. .... R. eupetraeum s. str.?

2. Medulla C+ red, KC+ red (olivetric? gyrophoric according to Timdal), P-, K-, (barbatic) or P+ orange, K+ yellow (stictic) or red (norstictic). Thallus thick, grey-brown to pale grey, sometimes white and sometimes violet tinged or pinkish brown, verrucose-areolate to bullate-verruculose; areoles becoming glebulose. Apothecia between the areoles, angular or rounded; margin thin or disappearing; disk flat, sometimes convex, matt. Epithecium reddish brown or olivaceous brown, usually K+ violet; hymenium brownish in upper part; paraphyses coherent. Spores 24-46 x 11-18  $\mu$ m, usually many-celled, often aborted, dark brown. Medulla weakly I+ blue. Cortex C+ pale pink. On exposed acid rocks, arctic to temperate, south to Tennessee, Michigan, South Dakota, Colorado, and California; Ontario. .... R. grande (= R. eupetraeum according to Feuerer, 1991; Timdal, 1988 accepts the two as morphologically as well as chemically distinct)

3. Medulla K+ yellow or red, P+ red, C+ red. Thallus grey to grey-brown, areolate; areoles small, strongly contiguous. Apothecia large, strongly projecting. Epithymenium K-. Spores  $\pm$  submuriform. Tennessee. .... R. intermedium (= R. eupetraeum according to Feuerer, 1991)

3. Medulla K-, C-. Thallus pale gray to brown. Spores 22-30-33(-36) x 10.5-15-16(-17)  $\mu$ m. Areoles not peltate; margins concolorous. Apothecia flat, with persistent margin. Medulla usually I+ faintly blue, K+ red or KC+ red. .... R. intersitum (= R. eupetraeum according to Feuerer, 1991; accepted as a separate species by Esslinger & Egan)

**Group III. Thallus white or whitish.**

**1. Thallus UV+ yellow.** ..... 2

**1. Thallus UV-.** ..... 3

**2. Spores 3-septate to muriform. Hypothallus thick, whitish; areoles whitish.**

**Prothallus greyish. Apothecia immarginate. Thallus P-, K-. ....** R. atroflavescens

**2. Spores 1-septate.** ..... (see Group I-A: R. eupetraeoides and R. inarense).

**3. Spores 1-septate.** Thallus areoles not umbilicate or subsquamulose. Thallus whitish. Medulla I-, K-, C-. Thallus subfarinose. Apothecia with a pruinose false-thalloid margin, sessile, disc plane, pruinose. Epithecium brown-violet, K+ purple. Spores 12-16(23) x 6-10(12)  $\mu$ m. On rock. .... (see R. chioneum)

**3. Spores 3-septate to muriform.** ..... 4

**4. On soil. Thallus dirty whitish ochraceous, indistinctly rimose or granulate, gelatinous when moist, K-, C-. Spores 3-4-septate to submuriform.** ..... R. athalloides

**4. On rock. Thallus chalky white.** ..... 5

**5. Epithecium pale brown to brown-black. Thallus rimose-areolate.** Spores 17-25  $\mu$ m. Apothecia  $\pm$  flat, margin thin or disappearing. (N. Am.?). .... R. subpostumum

**5. Epithecium blue-black or olive-black. Thallus continuous, thin.** Apothecia 0.5-1 mm. Apothecia with thick margin, pruinose. Calcicolous. .... 6

**6. Apothecia flat, not in botryose clusters; margin thick to very thick, pruinose.**

**Spores 18-24-30 x 10-14-16  $\mu$ m.** Apothecia little to distinctly projecting above thallus, to 2 mm wide; disc rarely also pruinose. Excipulum occasionally with algae. On calcareous rocks, in relatively moist and cool sites. Arctic-alpine, Ellesmere Island to Alaska. .... R. umbilicatum

**6. Apothecia in convex botryose clusters, margin pruinose or not. Spores 12-14 x 5.5-7.7  $\mu$ m.** Arctic, rare. .... "R. cumulatum" (may belong in Buellia according to Feuerer 1991)

ADD:

Colorado? ..... R. santessonii Timdal (see Weber, 1990)

R. subtile = R. viridiatrum

## Descriptions

### **R. arctogenum**

Thallus of small, 0.4-0.8 mm broad, peltate and convex areolae with gray pruinose margins, round or angular, brown, often shining; underside dark; over black hypothallus which has diffuse or radiate edge.

Apothecia grouped or dispersed, adnate or sessile between areolae; margin thin, persistent or disappearing; exciple dark brown in exterior, paler within; disk black, epruinose, becoming roughened and convex; hypothecium brown to black; epithecium brown or slightly violet; hymenium 120-150 µm, hyaline or pale violet; paraphyses 2 µm, tips 3-4 µm and brown, upper cells partly constricted; spores 4-5 per ascus, muriform, oblong-ellipsoid, often slightly bent, becoming dark, 31-50 x 10-120 µm.

Medulla K-, C- or C+ red (areolae on same thallus), I+ blue; hypothecium K-; epithecium K- or K+ more violet. On siliceous rocks in dry to slightly moist areas and on rocks in snowmelt areas. Greenland; Arizona.

### **R. bolanderi**

Thallus 2-7 cm diam.; areoles 0.6-1.3 mm dim., 0.25-0.35 mm thick, concave or subplane, brown or reddish brown, shining or matt, margins thick, prominent, incurved, generally wavy sinuate, incised, black or gray, subpulverulent; lower side dark, often easily visible, narrowly fixed to substratum. Hypothallus black, rather thick; edge radiating or diffuse; septa constricted, articuli dark, K-. Epinecral layer 20-40 µm thick, when often old falling off, leaving the cortex exposed. Upper cortical end cells brown or brownish violet, 4-7 µm broad; uncolored cortex 25-40 µm thick, formed of (6-)8(-10) articuli, distinctly seen as a colorless layer above the algal layer. Algal layer 45-80(-100) µm deep, generally occupying less than one third of areolar height; algae 10-14 µm diam., equally dispersed or grouped in islets; medulla uncolored, cells almost isodiametric, 5-6 µm broad; lower cortex dark brown or grayish violet, cells 5-8 µm, nearly isodiametric, outermost 4-5 cells very dark; end cell layer uneven; epinecral layer absent on lower side.

Apothecia 0.6-1 mm diam., 0.2-0.35 mm thick, dispersed, adnate or sessile between the areoles; disc black, epruinose, finally rugulose and convex; margin black, subpersistent or disappearing; excipulum 60-70 µm thick in lateral part, black or brownish violet in outer zone, lighter inwards, K+ more distinctly violet, exceptionally with brownish violet mist; "pulpa" (hypotheoid tissues) to 800(-1000) µm diam. and to 300 µm thick, brown (black), K-, I-, upper surface convex, "paraphysogenous tissue" to 40 µm thick, forming a rather continuous layer, slightly or not imbedded in "pulpa"; ascogenous cells c. 10 µm diam., slightly imbedded in "pulpa"; hymenium hyaline or pale violet, 100-135 µm, violet color more distinct in K; paraphyses loosely conglutinate, branched, septate, 2-3 µm broad in lower parts, 3-5 µm at apices; epithecium brownish violet, K- or K+ distinctly violet; asci saccate or inflated, 80-110 x 22-30 µm; spores 2 or 1 per ascus, multilocular, oblong-ellipsoid, (32-)40-50(-68) x 18-32 µm, hyaline



then green or violet, finally dark; wall 2 um; halo 3-4 um, in k 4-6 um.

Cortex K-, C, KC-, P-; medulla I-, K+ yellow or K-, P-, C-, KC-.

On siliceous rocks, often on seepage surfaces but also on drier, often manured, surfaces. California to Washington; Greenland.

### **R. rittokense**

Thallus to 15-20 cm diam.; areoles 0.5-1.2(-1.5) mm diam., 0.2-0.35 mm thick, concave, subplane or convex, round, brown, often shining, pruinose towards margin, margin rather thick, prominent, dark, subpulverulent; when damaged and decorticated white, medulla being visible; lower side dark, not visible in situ, rather narrowly fixed. Hypothallus black, rather thick; upper surface often cracked, white; edge mostly radiating; septa constricted, articuli dark, K- or slightly violet. Epinecral layer 20-35 um, when old often falling off; upper cortical end cells brown, 4-5 um broad; uncolored cortex 15-20 um thick, formed of 3-5 articuli; algal layer 60-80(-100) um thick, occupying less than half areolar height; algae 8-12 um, equally dispersed or grouped in islets; medulla grayish or clear, cells almost isodiametric, 5-6 um broad, penetrating high up into areolar margin; lower cortex dark, cells 4-6(-8) um, outermost 2-3 cells very dark; end cell layer even; epinecral layer absent.

Apothecia 0.6-1.6 mm diam., 0.2-0.4 mm thick, dispersed or grouped 3-5 together, adnate or sessile; disc black, epruinose, finally rugulose and convex; margin black, thin, subpersistent; excipulum 60-70(-100) um thick laterally, almost black in outer zone, lighter inwards, K- or K+ dilute violet; hypothecial tissues to 600 um or more diam., to 220(-250) um thick, K-, I-, upper surface convex; paraphysogenous tissue forming a diffuse, poorly delimited layer at base of paraphyses, 25-40 um thick, partly imbedded in hypothecial tissue; ascogenous cells 7-8 um, unevenly dispersed in paraphysogenous tissue or imbedded in hypothecial tissue; hymenium hyaline, 100-140 um; paraphyses conglutinate, branched, septate, 2 um wide at base, 3-4 um at tips, top cell brown; epithecium brown, K- or K+ dilute violet; asci saccate, 90-140 x 25-40 um, the lower end often imbedded in hypothecial tissue; spores 8, 1-septate, ellipsoid, 20-24 x 10-15 um, green, then brown or black, often shrunk, wall 1-1.2 um, halo 2-3 um, in K 3-4 um..

Thallus K-, C-, KC-; medulla I-, P- (in aberrant material differing reactions).

On siliceous rocks, on dry, wind-espoused surfaces more or less snow-free in winter; also on more sheltered surfaces, irrigated for a short time in early spring, apparently ornithocrophobous. Eastern Arctic of Canada; Greenland.

### **R. umbilicatum**

Thallus epilithic, chalky white, areolate; areoles 0.5-2.5 mm wide, separated by narrow fissures, without dark prothallus.

Apothecia 0.2-0.9 mm wide, black, immersed, concave, with a broad gray rim; hymenium 120-140 um; epihymenium green-black; paraphyses distinctly anastomosing; spores 21-30 x 10-15 um (excluding epispore), muriform with 8-16 cells,  $\pm$  hyaline. Especially on shaded vertical surfaces, also on pebbles. Calcicolous. Arctic-alpine.

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