After the flood: Investigations of impacts to archaeological resources from the 2013 flood in southern Alberta

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Recognizing macrofossils: A pictorial guide to some common seeds and shells from alluvial deposits in southern Alberta

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ABSTRACT

Macrofossils such as seeds and shells are excellent resources for reconstructing past environments. Assemblages of these remains provide context for archaeological and palaeontological studies. This paper reviews diagnostic characteristics and presents microphotographs of fossil and modern specimens of taxa commonly encountered in near-stream sediment samples from a southern Alberta flood investigation program. Four examples each of terrestrial gastropods, aquatic gastropods, and wet area plants are detailed. The goal of this paper is to provide critical identification information about the target taxa to non-specialists. We hope that this will promote the further collection of macroremain-rich samples and provide a foundational approach for describing seeds and shells. The identification of macrofossils need not be arduous, and with the right tools, including a comparative reference collection and literature as a guide, even beginners can quickly and reliably identify some common taxa.

KEYWORDS

Macrofossil, identification, seeds, palaeoenvironment, molluscs, microscopy, SEM, Alberta, alluvial, riparian

1. Introduction

Faunal and floral macrofossils, animal and plant remains visible with the naked eye (though often only identifiable through microscopy), are common palaeoenvironmental indicators recovered from sediment samples. Macrofossils include a vast array of small organisms and remnants of past life. Pieces of wood, leaves, and insect remains are all macrofossils, but our focus here is on seeds and mollusc shells. The analysis of macrofossils provides context for archaeological and palaeontological studies but is also useful for providing ecological data for the development of detailed, locality-specific (e.g., Bolton 2017) and larger scale, regional, palaeoenvironmental reconstructions (e.g., Bolton and Beaudoin 2017).

Recently, as part of Alberta Culture and Tourism's flood impact assessment program in southern Alberta, we have analyzed macrofossils extracted from sampled flood deposits and other alluvial sediments collected from the banks and riparian areas of select southwest Alberta streams, namely the Highwood, Bow, and Kananaskis Rivers, as well as Fish, Tongue, and Jumpingpound Creeks. Although a large variety of macroremains were found in these samples (at least 539 unique taxa/forms/ontogenic stages), some taxa were very common and occurred in most assemblages. Only a few of the more than 40 samples processed lacked any of the common taxa. On the other hand, many samples had multiple common taxa represented.

In this paper we highlight a few of the most common taxa detected in the flood deposits, describing their general morphologies and providing light microscope (LM) photographs of fossil macroremains, modern comparative material, and scanning electron microscope (SEM) images of specimens where available. All taxa discussed are native to Alberta and much of western Canada and thus could be expected in samples from any time during the postglacial interval (the last 11,000 years). For molluscs, fossil specimens often lack the periostracum—the thin outer organic coating or "skin" of the shell. Thus, colour patterns on fossil and modern shells in the same taxon may differ. However, characteristics such as size, shape, coiling habit, size and structure of the aperture, and surface sculpturing persist even in highly weathered specimens. These characteristics usually form the basis for identification. Similarly, for seeds, appendages may often be lost on fossil specimens but overall morphology, size, and structure persist and form the basis for identification.

Our goal is to provide an accessible primer for researchers or interested non-specialists to help them identify some macrofossils frequently found in alluvial/riparian contexts. We suspect that in many cases macrofossils are often overlooked during field assays due to their small size, and perhaps because they are "out of the speciality area" of the individual. We hope to show that it is worth taking a little extra care to check for macrofossils in the field and that the identification of many commonly occurring seeds and shells need not be onerous.

2. Microphotography and descriptions of common taxa

The following photographs were taken of fossil macroremains collected and analyzed as part of Alberta Culture and Tourism's flood impact assessment program in southern Alberta and modern specimens from the Royal Alberta Museum (RAM)'s Quaternary Environments program modern reference collection. Each figure row (two to four images) has a consistent scale (image bar is 1 millimetre long), except in enlarged images where the scale factor is noted. Although effort has been made to keep the scale of images vertically in sync within each figure as well, due to variability in specimen size, alternate scaling was necessary for some rows.

For each taxon, a brief highlight of its most striking morphological characteristics and its general ecological niche is presented under the sub-heading "The basics". More thorough descriptions of each taxon, intended for positive identification, are presented under the sub-heading "The details". We have appended at end of the paper, a glossary of terms used in the descriptions, the meaning or use of which may be unfamiliar to non-specialists.

2.1 Terrestrial gastropods

2.1.1 Discus whitneyi

The basics: Known as the forest disk snail, *D. whitneyi* is a common terrestrial snail presently found in large swaths of the United States and Canada. Its shell is flatly coiled with distinctive ribs radiating from its apex.

The details: The shells of *D. whitneyi* may be as wide as 6.5 millimetres but are usually smaller (Hendricks 2012:125). Its key diagnostic characteristics include a flattened heliciform morphology with a somewhat convex aperture, as well as radial ribs visible over nearly all the shell, including on the interior of the open umbilicus (Hotopp et al. 2013; Figure 1). The only region that lacks ribs is the nuclear region (Forsyth 2004:82). Another species with axial ribs is *Vallonia gracilicosta*. However, that taxon's ribs are generally less dense than those of *D. whitneyi* (though our analysis of modern and fossil specimens reveals this is not always the case), and are populated with finer striae between. Some fossil specimens of *D. whitneyi* exhibit eroded periostracum, and in some cases the axial ribs, particularly on the bottom of the body whorl, are faint or seemingly lacking. To verify that shells of this description are not the related species *D. shimeki* (which lacks umbilical ribs), check the interior of the umbilicus for ribs; in *D. shimeki*, they should be absent.

2.1.2 Euconulus fulvus

The basics: The brown hive snail, *E. fulvus*, takes after its namesake, with a beehive-shaped shell that is smooth at first glance. This snail is common at grassy or forested sites.

The details: *E. fulvus* possess shells up to about 3.5 millimetres wide that are slightly shorter than wide, translucent brown, silky in lustre, and though superficially smooth-surfaced, they are covered in fine, closely spaced axial threads, and even finer spiral striae (though sometimes the striae are absent; Forsyth 2004:94). Shells grow up to about five and a half whorls, with narrowly crescent-shaped apertures, and their umbilici are tiny or entirely closed (Forsyth 2004:94). Apertures are often broken (Figure 2, both modern and fossil specimens), though the beehive-like shell morphology and other basic characteristics are still normally preserved.

2.1.3 Succineidae

The basics: A family of thin-shelled land snails, often amber in colour, the Succineidae, are broadly called "amber snails". The size of their apertures and body whorls relative

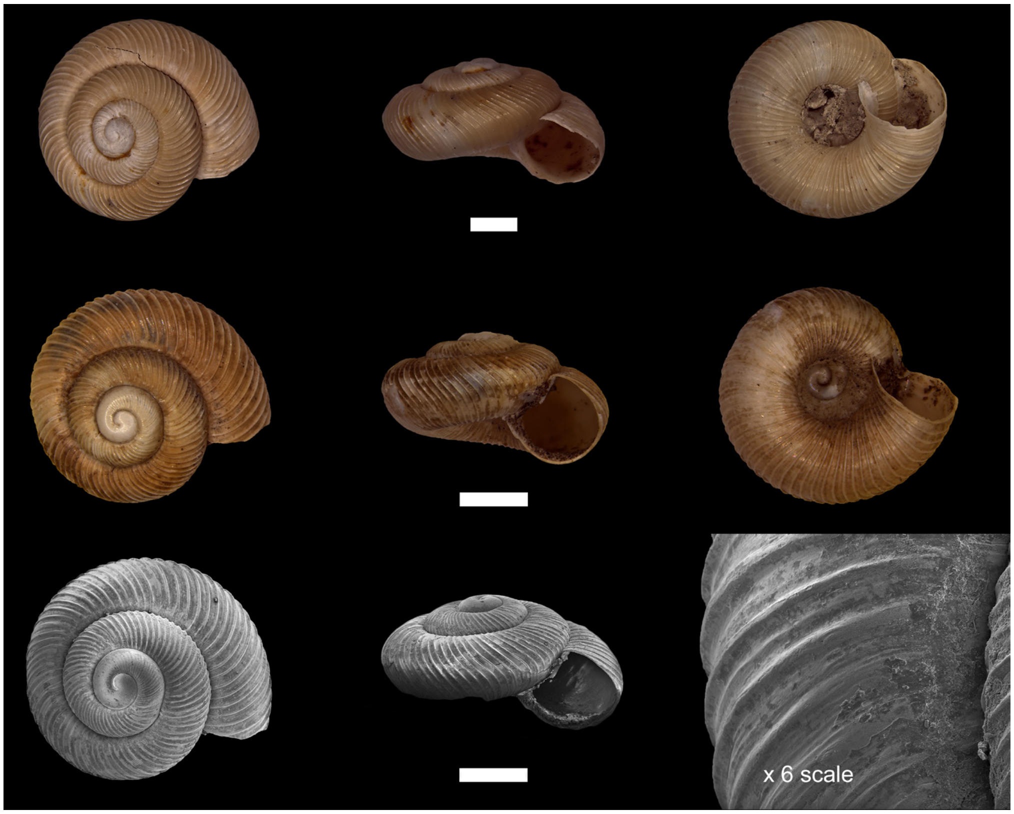

Figure 1. Microphotographs of *Discus whitneyi* shells. Top: fossil LM; middle: modern LM; bottom: modern SEM, right image shows body whorl axial rib detail.

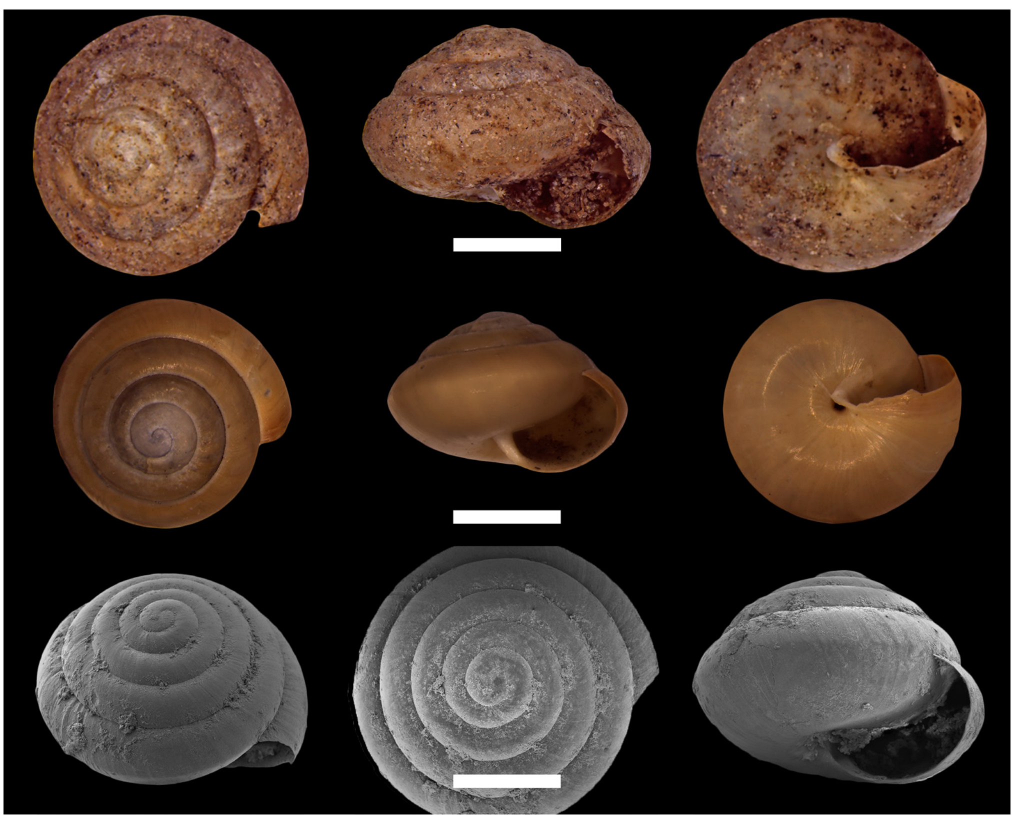

Figure 2. Microphotographs of *Euconulus fulvus* shells. Top: fossil LM; middle: Modern LM; bottom: fossil SEM.

to their spires is remarkable and allows for relatively quick identification to the family level. They are typical of wetland, or especially wet, sites, though they are surprisingly wide-ranging, and globally, are actually more representative of dry climate than other taxa detailed here (Bolton and Beaudoin 2017).

The details: Succineidae have conispiral shells that are identified by their large apertures and very rapidly expanding body whorls (i.e., they exhibit "succiniform morphology"). Shells of this family are generally smooth-surfaced, though axial threads are normally visible (Figure 3, especially SEM images, bottom). Succineid taxonomy is complicated and constantly shifting; further, the features most useful for identification, particularly the animal's soft anatomy, chiefly sex organs, are not ordinarily preserved, even in modern specimens found dead (Figure 3, middle). Unfortunately, identification to species based on shell morphology is not feasible (Burch 1962:67; Forsyth 2004:39). As such, we, as with most macrofossil researchers, halt succineid shell identification at the family level.

2.1.4 Vallonia gracilicosta

The basics: One of the most common riparian land snails, *V. gracilicosta*, the multi-ribbed *Vallonia*, is typified by its rather small size, prominent axial ribs, and its thickened and expanded aperture that forms a rim.

The details: *V. gracilicosta* shells grow to about 2.9 millimetres in width and 1.2 millimetres high, and are flattened heliciform in shape with widely spaced lamellar axial ribs (Hotopp et al. 2013). In modern specimens, the shells are normally translucent whitish to pale brown, though, like *Gyraulus* snails (section 2.2.1), fossil specimens are normally markedly opaque (Figure 4). Probably the most diagnostic feature of this species is the rather strongly prosocline aperture and, especially, its thickened apertural lip. Although it is frequently damaged, or even broken off on fossil specimens (Figure 4), it is robust enough that even in cases where the rest of the shell is not well-preserved, the c-shaped aperture rim still survives and is identifiable.

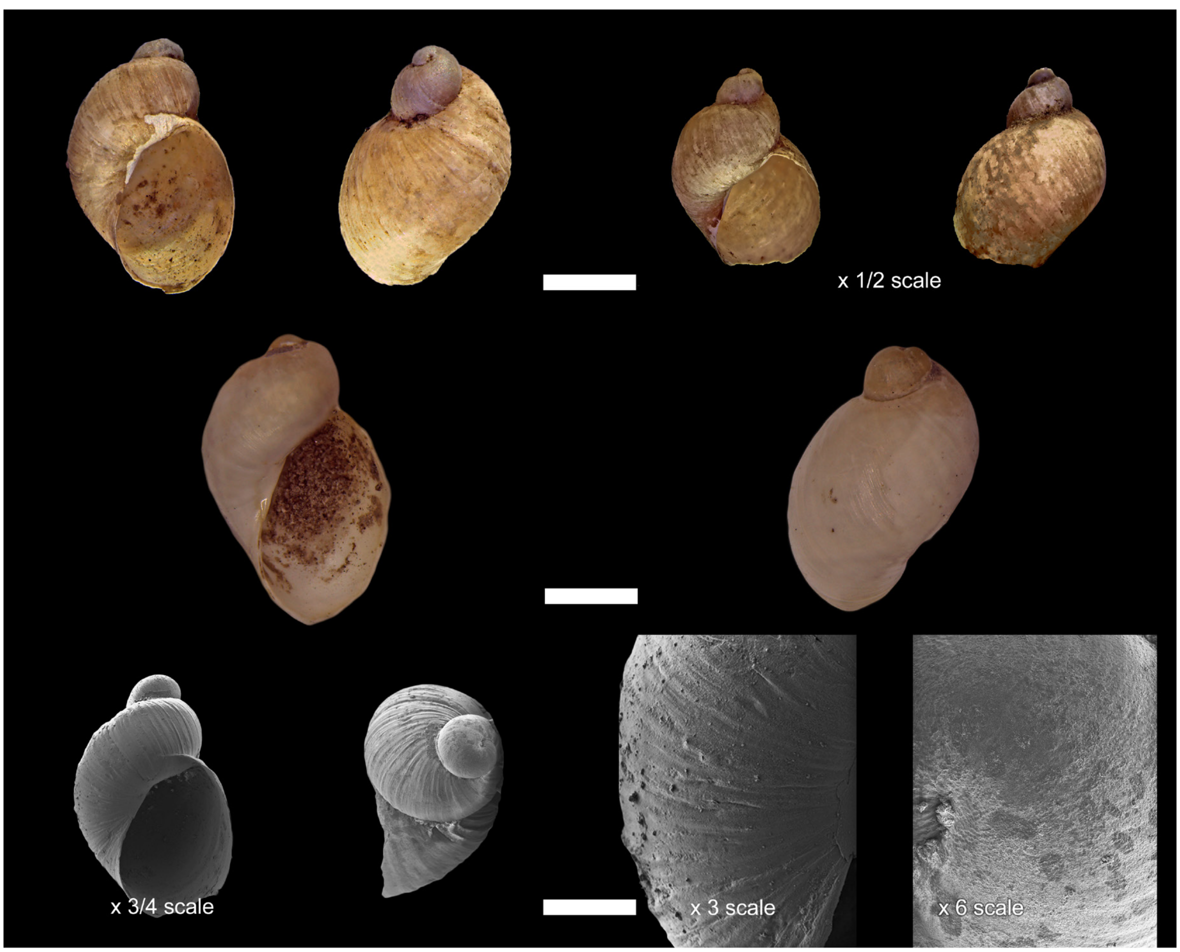

Figure 3. Microphotographs of Succineidae shells. Top: fossil LM (left and right are two specimens); middle: modern LM; bottom: fossil SEM, middle right image shows body whorl surface detail, far right shows spire/nuclear region detail.

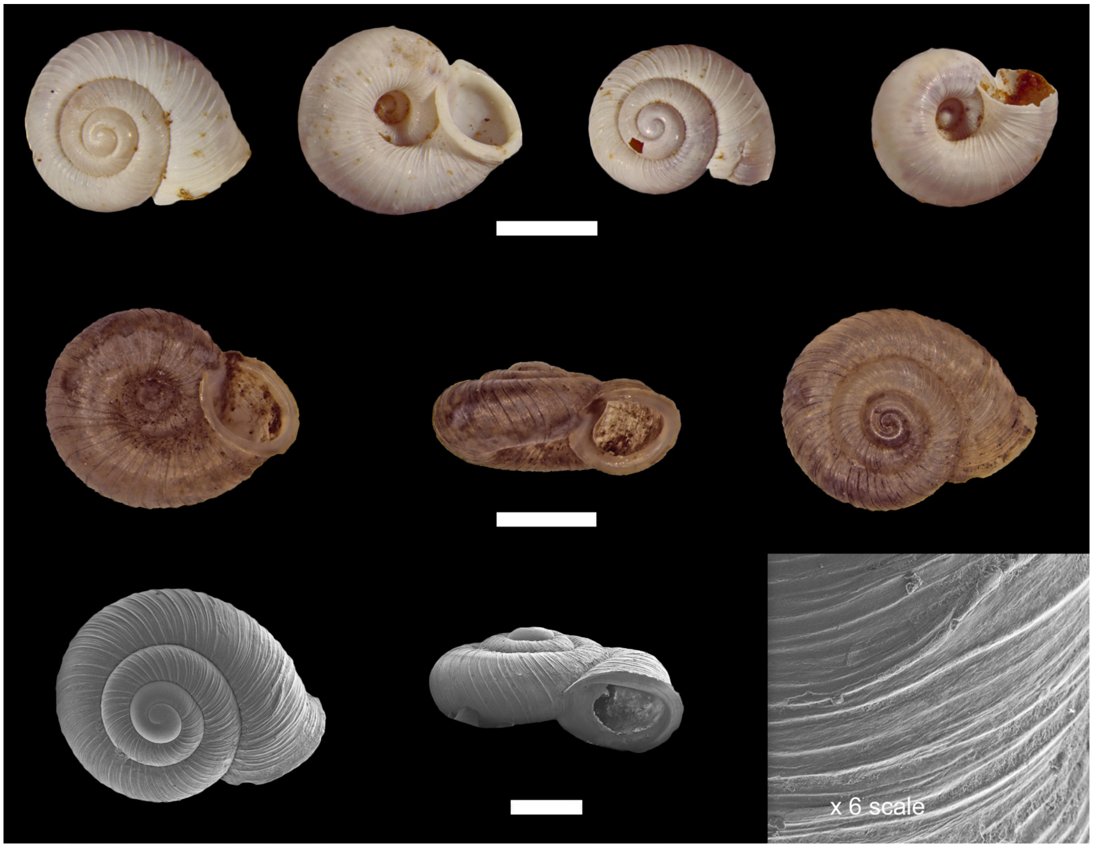

Figure 4. Microphotographs of *Vallonia gracilicosta* shells. Top: fossil LM, middle: modern LM; bottom: modern SEM, far right image shows body whorl surface detail.

2.2 Aquatic molluscs

2.2.1 Gyraulus circumstriatus

The basics: A rather minute aquatic snail of pools, ponds, and small streams (Clarke 1981:176), the disk gyro snail, *G. circumstriatus*, is flatly coiled and almost transversely symmetrical with slowly increasing whorl size.

The details: Shells of *G. circumstriatus* are flatly planispiral, dextrally coiling, and often semi-transparent (Clarke 1981:176). Many fossil specimens are opaque instead of transparent (Figure 4), possibly due to aragonite remineralization following groundwater percolation or weathering. Their shells are up to 5 millimetres wide and 1.5 millimetres tall (Clarke 1981:176), though as seen in Figure 5, less mature specimens (exhibiting fewer than four whorls) are much smaller, often only around 2 or 3 millimetres. Because the two sides of the shell are mostly symmetrical (and the ovate aperture is only slightly prosocline, unlike *G. parvus* and *G. deflectus* which diverge from the medial line more noticeably), both apical and umbilical views present almost identically—just with mirrored spiral patterns. The shell sculpture is very fine striae and growth lines, and, when the periostracum is well-preserved, it is smooth and shiny (Clarke 1981:176).

2.2.2 Helisoma anceps

The basics: The two-ridged ram's-horn snail, *H. anceps*, an obligate permanent-water snail, is characterized by its rather prominent carinal ridges on both umbilical and apical faces. Its right-handed coiling helps differentiate it from other similar taxa.

The details: *H. anceps* possess dextrally coiling shells that can be up to 2 centimetres wide and 12 millimetres high, with as many as four and a half whorls, though most specimens are much smaller (Figure 6; Clarke 1981:198). The most defining characteristics of this shell's morphology include double carinae as well as fine axial striae. To separate this species from similar ridged snails (e.g., *Planorbella* spp., a sinistral genus) the direction of coiling is important. The umbilicus of *H. anceps* is deep and rather narrow (Clarke 1981:198), whereas the apical face is not so impressed. The ear-shaped apertures of this snail are often marginally expanded (Figure 6, top), although this enlarged region is often damaged or missing, particularly on shells that have been transported or are immature (Figure 6, middle and bottom). These shells are apparently quite fragile and are rarely found whole.

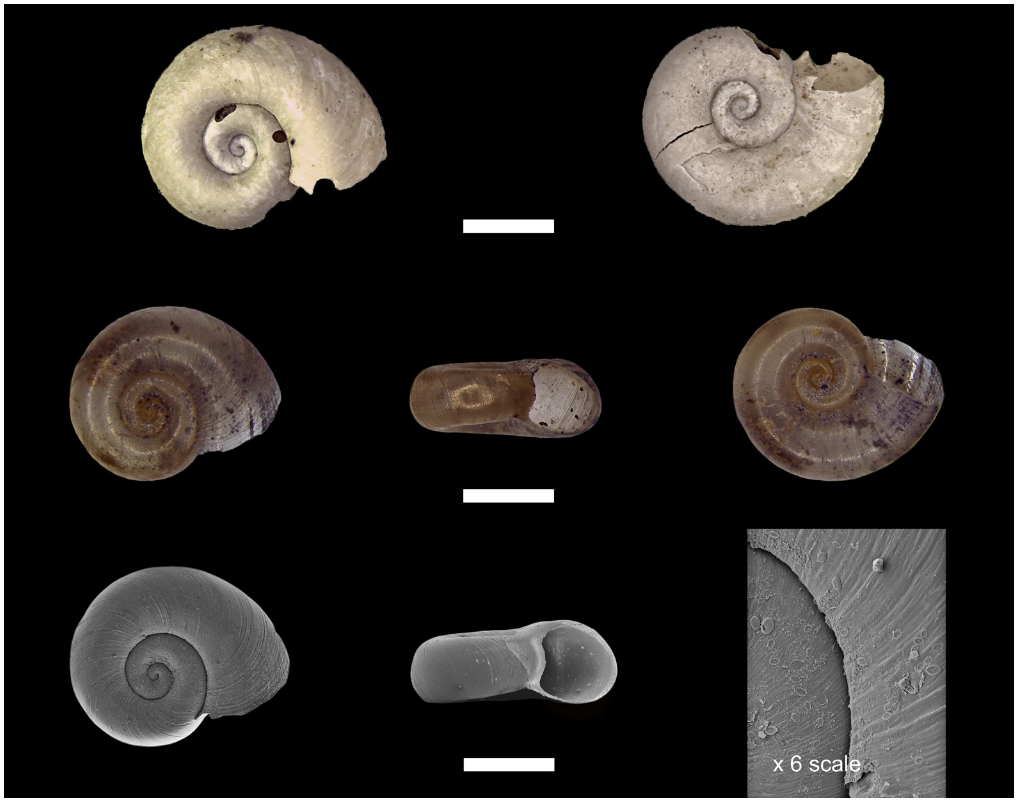

Figure 5. Microphotographs of *Gyraulus circumstriatus* shells. Top: fossil LM; middle: modern LM; bottom: modern SEM, far image right shows body whorl suture detail.

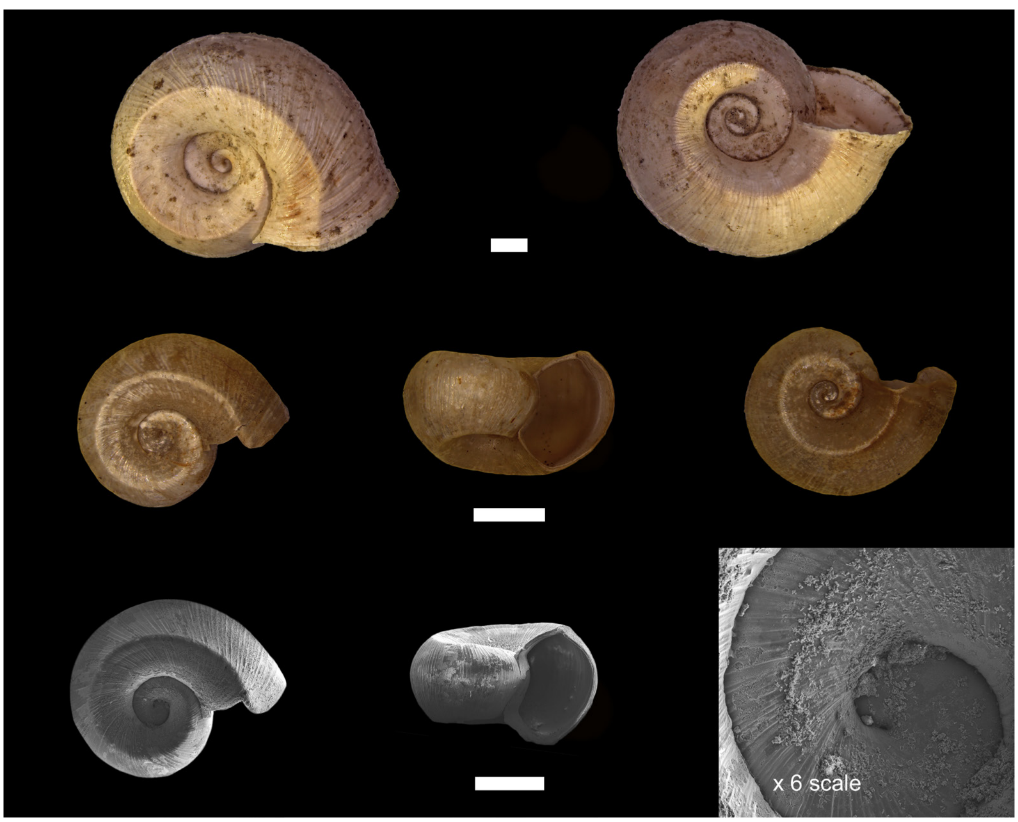

Figure 6. Microphotographs of *Helisoma anceps* shells. Top: fossil LM; middle: modern LM; bottom: modern SEM, right image shows apex surface detail.

2.2.3 Physa gyrina

The basics: Probably one of, if not the most, frequently encountered, sinistrally coiling snail in Alberta, *Physa gyrina*, the common tadpole snail, features a short spire and rapidly expanding whorls, resulting in a very large aperture on the left side.

The details: *P. gyrina* possess delicate shells which can grow up to five and half whorls and up to 24 millimetres high (16 millimetres wide; Clarke 1981:152), though few reach this size—most are under a centimetre high. The most striking feature of this snail, aside from its coiling direction, is its large aperture and body whorl—comprising as much as 80 percent of the shell height. The whorls are "gently rounded and loosely coiled, that is, overlapping the previous whorl only to a line that is below, or at the periphery of that whorl" (Clarke 1981:152). This can be seen particularly clearly in the SEM images of Figure 7 (bottom). Despite how relatively common *Physa* shells are in the macrofossil-rich fluvial sediment samples we studied, we suspect that due to their fragile nature they are probably under-represented (i.e., their shells are often reduced to unidentifiable fragments) in our and other macrofossil assemblages, especially those that were significantly transported before deposition. For this reason, special care should be taken to prepare samples as delicately as possible. Their recovery may justify extended soaking and/or the use of disaggregation agents (e.g., sodium pyrophosphate) in macrofossil sample pre-treatment to reduce the need for mechanical agitation (see Beaudoin 2006, 2007).

2.2.4 Pisidium spp.

The basics: Small "pea clams" of the genus *Pisidium* are common in samples of both lacustrine and riverine origin. They look like miniature versions of the large marine clams with which most people are familiar. Most often, the shells are disarticulated (i.e., with valves separated), though very occasionally, especially in relatively recent samples, the valves can remain together.

The details: Adult shells are normally small—only 3 to 11 millimetres—and rarely over 5 millimetres long, typically with an obliquely oval shape, and usually with an offset hinge relative to the umbo (Killeen 2009:24). Another genus from this family, *Sphaerium*, is superficially similar to *Pisidium*, but their valves are normally larger—from 8 to 20 millimetres—and have more centrally positioned beaks. Admittedly, identification to species within this genus is not always straightforward, but invariably, the arrangement, size, and shape of the hinge teeth or lateral cusps are important diagnostic features. This assessment requires the comparison of left and right valves; distinguished by the

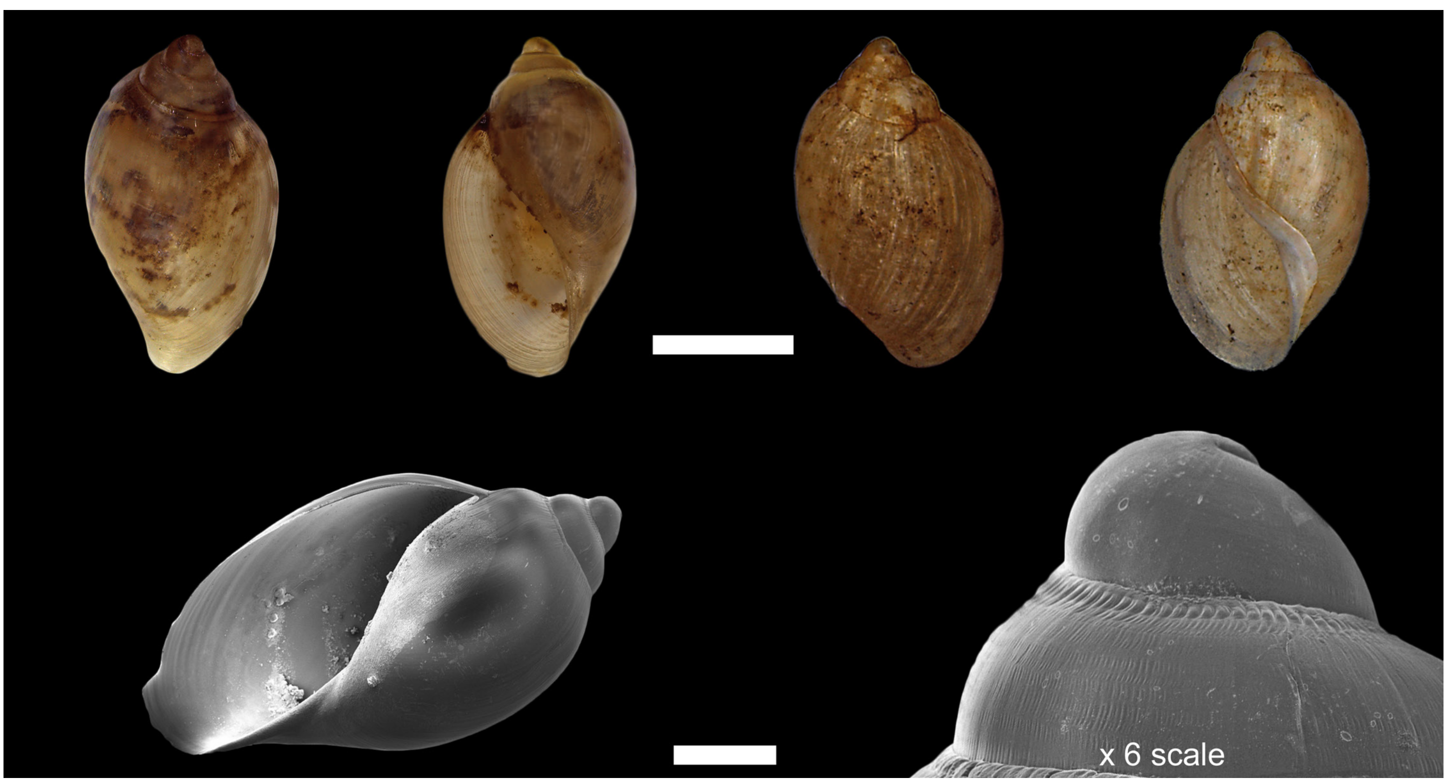

Figure 7. Microphotographs of *Physa gyrina* shells. Top left: fossil LM (front and back); top right: modern LM (front and back); bottom: modern SEM. Bottom right image shows spire/nuclear region detail.

possession of single lateral cusps on either side of the left valve, double lateral cusps on the right (Figure 8, bottom right), as well as a pair of stacked cardinal (hinge) teeth on the left valve, and only a single cardinal tooth on the right valve (Figure 8, top right). For guidance in identifying members of this taxon to species, see Clarke 1973 and 1981. Normally, we identify these to the genus level only.

2.3 Emergent and aquatic plants

2.3.1 Eleocharis palustris

The basics: The "seeds" of the emergent wetland plant, *E. palustris*, the common spikerush, are technically achenes. The achenes feature noticeable pyramidal tubercles on a shield-shaped body.

The details: Achenes are normally about 1.5 millimetres long, yellow to brown in colour, and smooth (to finely rugulose) in texture (Moss 1983:158). Tubercles are normally pyramidal (although sometimes mammillate, especially when weathered) from 0.3 to 0.7 millimetres (Reaume 2009:567). The achenes are subtended by three to six retrorsely barbed perianth bristles (Reaume 2009:567), though these are often lacking or only one or two may be present, particularly in fossil specimens. Basal bristles seem to be easily lost or broken and so are often missing on fossil specimens. Note, as in the top row of Figure 9, macrofossils may variously lack or maintain tubercles or bristles, but even when these features are missing, the shape, texture, and apical/hilar scarring are still diagnostic.

2.3.2 Potamogeton spp.

The basics: *Potamogeton*, or pondweeds, are aquatic plants that bear distinctive "ear-shaped" fruits with trap doors that open along their backs.

The details: Though sometimes called achenes, *Potamogeton* seeds are technically dehiscent fruits, owing to their dorsal "trap doors". Often these trap doors are partially or wholly separated from the main fruit body, and even when found alone, are sufficiently diagnostic to be identified at least to genus, and sometimes species. Many specimens exhibit a dorsal keel (along the trap door), although the size and form of this feature can be variable within each species, and can be challenging to interpret in fossil material because what may have been a "smooth" keel in life may resolve as a "ragged" or "serrated" keel in weathered specimens. Also, *Potamogeton* fruits often have diagnostic apical styles (referred to in some literature as "beaks"). Again, care should be taken when interpreting this feature, because physical processes (e.g., weathering) or developmental nuances may impart unexpected inconsistency in their shape

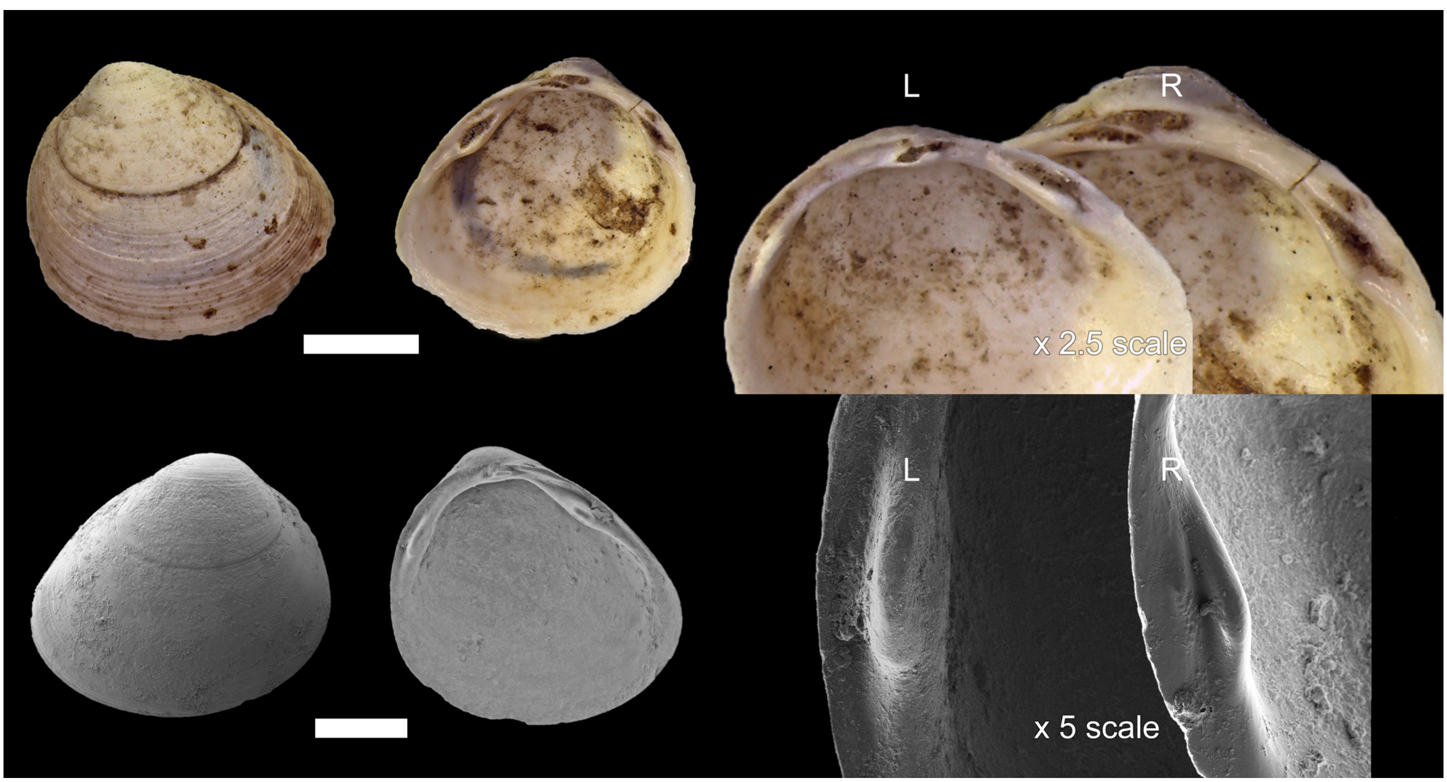

Figure 8. Microphotographs of *Pisidium* valves. Top: fossil LM, right images show hinge detail; bottom: fossil SEM, right images show cusp detail. Initials (L and R) indicate valve handedness.

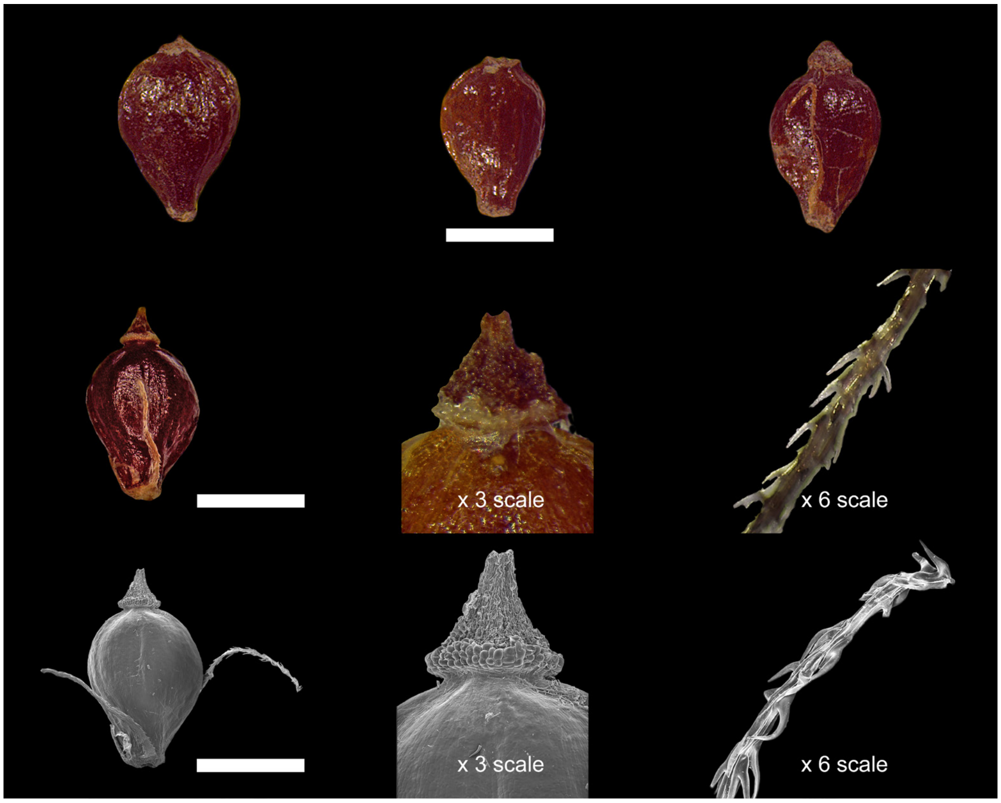

Figure 9. Microphotographs of *Eleocharis palustris* achenes. Top: fossil LM; middle: modern LM; bottom: modern SEM. Middle and bottom middle images show tubercle detail; right images show bristle detail.

and size. The embryos, coiled once or more, impart an overall "earlike appearance" to *Potamogeton* fruits (Martin and Barkley 1961:127; Figure 10). Surface textures range from smooth to rugose, but most are rugulose (Figure 10, especially bottom right).

2.3.3 Scirpus microcarpus

The basics: Small-fruited bulrush, *S. microcarpus,* fruits are tiny and easy to miss. Luckily, their small size is helpful for identification and, combined with their finely pointed apex and light colour, makes them relatively easy to identify. In well-preserved specimens, distinctive bristles attached to the base of the fruits can be diagnostic.

The details: The achenes of *S. microcarpus* are uncharacteristically small for the Cyperaceae (sedge) family, only about 1 millimetre long (Moss 1983:165), ranging from 0.7 to 1.6 millimetres (Reaume 2009:575). The light tan to whitish achenes can be plano-convex to trigonal in cross-section, are apiculate (possessing a short, sharp beak), and are subtended by usually three or four barbed perianth bristles (Reaume 2009:575), though these are frequently missing, especially in fossil specimens (Figure 11). Schuyler (1971) noted that the epidermal cells of *S. microcarpus* exhibit undulating cell walls, and generally have one convex central body per cell, though our investigations revealed that, though these bodies are typical, they are not always present (Figure 11, bottom right).

2.3.4 Zannichellia palustris

The basics: Fruits of the horned pondweed, *Z. palustris*, another aquatic plant, are elongate, narrow, and recurved. In short, they possess a banana-like appearance that is quite unlike any other Albertan seed.

The details: The fruits of *Z. palustris* are between 2 and 4 millimetres long, and possess a toothed ridge on the central dorsal surface as well as an apical style up to 1 millimetre in length (Moss 1983:58). The endocarp of the fruits is often coarsely papillose in texture, especially after decay or removal of the outer cellular wall; otherwise, the surface is normally longitudinally striate to areolate (Montgomery 1977:152). Fossil specimens often lack the beak-like style and are very often split, either in the dorsal-ventral axis (Figure 12), or, less commonly, in the left-right axis. This is important to note in quantitative studies of macrofossil assemblages because an abundance of *Z. palustris* fruit fragments may actually represent around half that number of individual fruits.

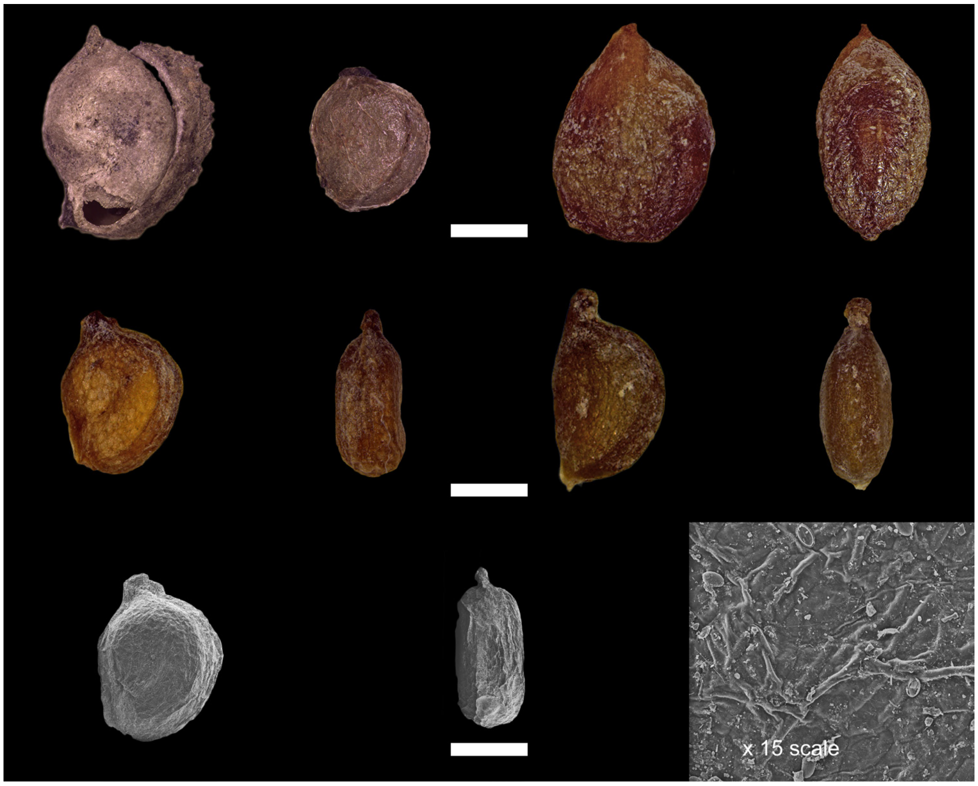

Figure 10. Microphotographs of *Potamogeton* fruits (multiple species). Top: fossil LM, far right: *P.* cf. *obtusifolius*, middle left: *P.* cf. *pusillus*, right: *P. vaginatus* side (middle right) and dorsal thickness (far right) views; middle: modern LM, left: *P. gramineus* side and dorsal thickness views, right: *P. friesii* side and dorsal thickness views; bottom: modern SEM, *P. gramineus*, side and dorsal thickness views, bottom right image shows side surface texture detail.

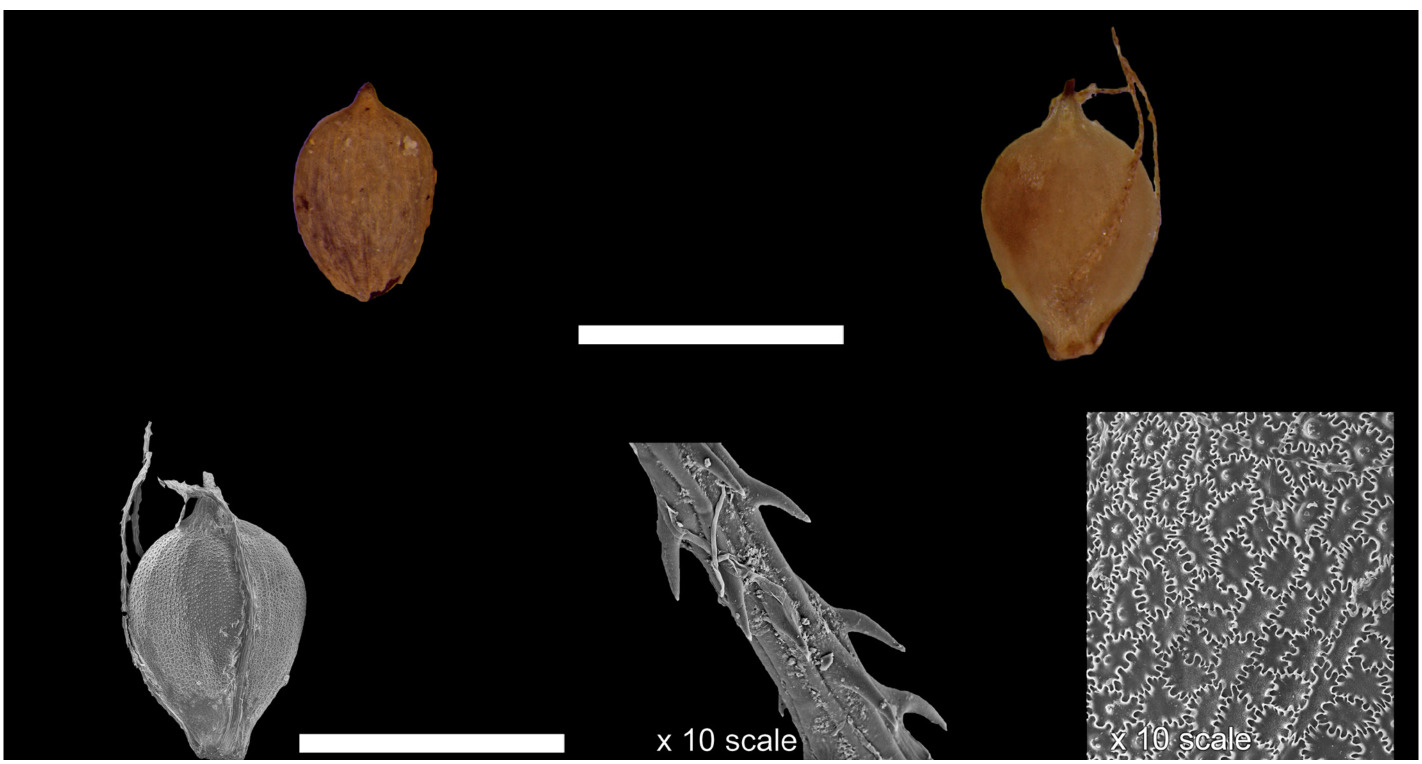

Figure 11. Microphotographs of *Scirpus microcarpus* achenes. Top: fossil (left) and modern (right) LM; bottom: modern SEM, middle image shows bristle detail, right shows achene surface detail.

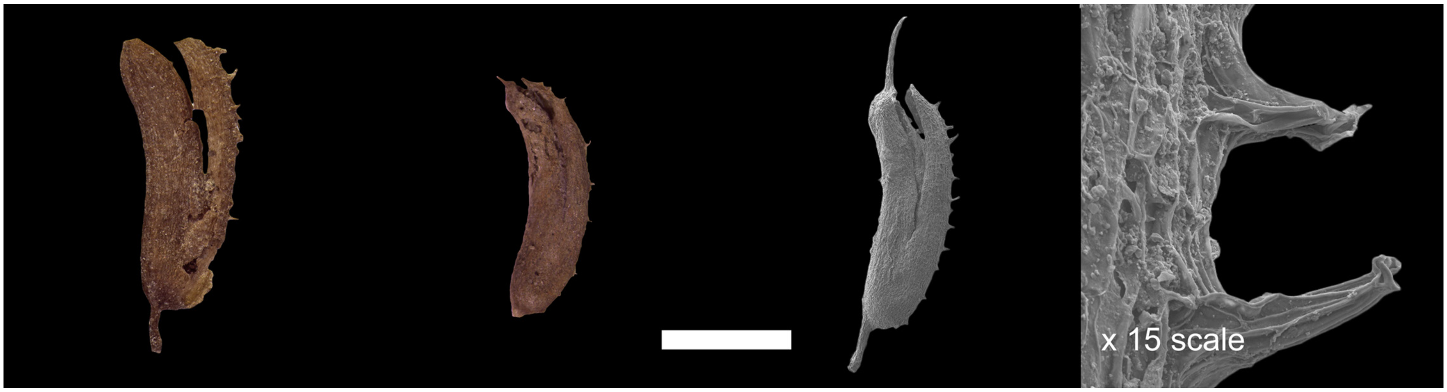

Figure 12. Microphotographs of fossil *Zannichellia palustris* fruits. Left: LM; right: SEM, far right shows dorsal wing spicule detail.

3. Conclusion

The floral and microfaunal macrofossils discussed in this paper, and the original sediment samples from which they were found, are held in the RAM's Quaternary Environments collection (accession numbers defined by the identifying field "QE2016." followed by site numbers "0328" to "0343" as well as "0346" to "0360"), Edmonton, Alberta. The Quaternary Environments program also maintains an extensive reference collection of modern comparative material. This material is available to consult by researchers at the museum and interested individuals for aid in identifying macrofossils of many taxa. Modern reference material photographed here were from the main seed reference collection (QE.2017.0002.0001; entity numbers S0201, S0231, and S2017) and from the mollusc collection of Prescott and Curteanu (2004), also part of the Quaternary Environments collection.

We hope that the reader gains familiarity with some of the most common macrofossils we have found in flood deposits from southern Alberta. Although even with well-preserved material, it is not always possible to identify entities to the species level, by knowing a few key morphological archetypes, one can make substantial progress toward identifying many macrofossils. With a little practice, in conjunction with the use of comparative reference specimens and good quality descriptive literature, even a non-specialist can make useful assessments of macrofossil assemblages, and most importantly, hone their ever-expanding palaeoenvironmental diagnostic toolset of identification skills and knowledge.

4. Glossary

Definitions of plant-related terms are adapted from Montgomery (1977), Moss (1983), and Harris and Harris (1994). Clarke (1981) and Forsyth (2004) were referenced for mollusc terms.

Achene: a dry one-seeded fruit that does not open to release the seed, and with the seed attached to the ovary wall at a single point.

Aperture: the opening in a spirally coiled shell through which the animal extends and retracts.

Apical: relating to the apex; towards the top.

Areolate: having a distinct but very fine network of spaces.

Axial: oriented along the axis; in discoidal forms, radiating outward, like spokes of a wheel.

Beak (of bivalves): the earliest formed part of a bivalve shell. See umbo.

Beak (of seeds and fruits): a narrow or prolonged tip, sometimes used synonymously with "style".

Body whorl: the last whorl of the shell, that is, most removed from the apex; where much of the body of the snail would reside.

Carina: a prominent spiral keel or ridge.

Conispiral: with a spire projecting as a cone. Cone-like.

Dextral: right-handed or coiled in a clockwise direction when viewed from above; when viewed from the front (with the apex upward) the aperture is on the right.

Dorsal: the back or upper portion of an object.

Endocarp: the inner layer of a fruit's wall.

Hilar: relating to the hilum, or scar on a seed marking the point of attachment to its seed vessel.

Hinge: the structure that joins the two halves of a bivalve shell at the dorsal margin, including articulating hinge teeth.

Keel: a ridge, like the keel of a boat.

Lamellar: thin and flat, often comprised of plate-like elements.

Macrofossil: A fossil discernible to the naked eye. Examples of plant macrofossils include seeds/fruits, leaves, needles, and stems; animal macrofossils include shells, exoskeletons, and bones. May refer to subfossil material (as in this paper). Synonymous with macroremains.

Mammillate: with nipple-like protuberances.

Nuclear whorl/region: referring either to the first (most-apical) whorl of a mollusc or the region of the spire which contains this whorl. The nuclear whorl is a remnant from the mollusc's larval shell.

Papillose: having minute, short, rounded nipple-like bumps or projections.

Periostracum: the outer parchment-like layer of a mollusc shell.

Planispiral: forming a flat coil. Planar.

Prosocline: with plane of aperture inclined away from the axis in its upper part, and toward the axis in its lower part.

Retrorse: directed backward or downward.

Rugose/rugulose: Exhibiting a wrinkled texture; rugulose indicates this characteristic to a lesser extent than rugose, meaning very finely wrinkled.

Sculpture: impressed or raised markings on an object's surface, especially mollusc shells.

Sinistral: left-handed or coiled in a counter-clockwise direction when viewed from above; when viewed from the front (with the apex upward) the aperture is on the left.

Spire: the upper surface of a spiral snail shell. In conispiral shells it is the part of the shell leading to the apex (excluding the body whorl); in planispiral shells the spire may be flat or concave but is recognizable because it is less concave than the umbilical side of the shell.

Striae: fine lines; either ridges or grooves.

Thread: a narrow, raised, usually spiral sculptural element.

Tubercle: a small tuber-like swelling projection; the base of the style in some members of the Cyperaceae.

Umbilical: relating to the umbilicus, the hollow centre (if present) of the axis of rotation of a snail shell, or less commonly, the hilum of a seed.

Umbo: a blunt or rounded protuberance; on bivalves, the apex of the shell, representing the juvenile shell (compare with nuclear whorl).

Ventral: the underside or lower portion of an object.

Whorl: a single complete turn of a spiral shell.

Wing: a thin, flat margin bordering a structure.

5. References

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