SEVEN MILLENNIA OF SALTMAKING

III CONGRESO INTERNACIONAL DE ANTROPOLOGÍA DE LA SAL | 3rd INTERNACIONAL CONGRESS ON THE ANTHROPOLOGY OF SALT

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Trajectoires

42. SURPLUS HOUSEHOLD SALT PRODUCTION IN THE CLASSIC MAYA ECONOMY

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SUMMARY

Survey and excavation of wooden buildings and associated briquetage at the Paynes Creek Salt Works indicate salt was produced by households in salt kitchens at sites that were submerged by sea-level rise. The sites are underwater in a salt-water lagoon system on the southern coast of Belize, Central America. The wood was preserved in red mangrove (Rhizophora mangle) peat that provided an anaerobic matrix for building posts that were driven into the ground when the pole and thatch salt kitchens were built. Brine was increased in salinity by pouring it over salty soil in canoes, as evidenced by piles of discarded soil at the only two sites above water in the mangroves, as well as a wooden canoe. The brine was boiled in pots over fires in the salt kitchens. Salt cakes and salted fish were transported by canoe up nearby rivers to inland communities where salt was scarce. As salt cakes, they became commodities that could be stored, traded, or kept for subsequent transactions, as currency equivalencies. The implications for salt production in the Maya area during the Classic period civilization (A.D. 300-900) are discussed with reference to other salt works lacking wooden buildings.

KEYWORDS

Salt cakes, salted fish, brine-boiling, wooden buildings, salt kitchens, Maya, Belize, marketplaces

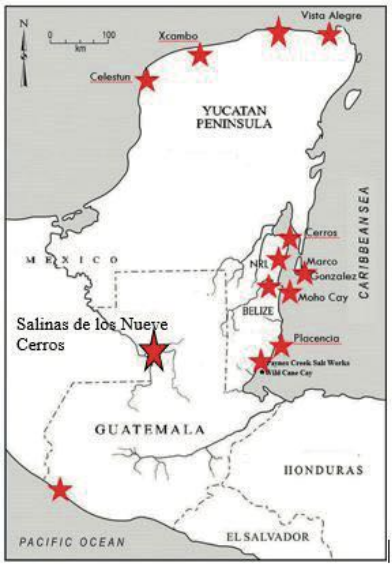

FIG. 1 *Map of the Maya Area showing the location of the Paynes Creek Salt Works and other salt works mentioned in the text.*

There were two methods of salt production in the Maya area, including solar evaporation along the north coast of the Yucatan peninsula of Mexico and brine-boiling along the coasts of Belize and Guatemala and in the highlands of Guatemala and Chiapas, Mexico (Figure 1). The Paynes Creek Salt Works are located in a shallow, salt-water lagoon on the coast of southern Belize (Figure 2). Since the discovery of wooden architecture preserved below the sea floor in 2004 (McKillop 2005a), research has focused on discovery, mapping, and excavations of the buildings, associated artifacts, and sea-level rise that submerged the sites and preserved the wood (Figure 3; McKillop 2010a, 2010b, 2018, 2019; McKillop and Sills 2017; McKillop et al. 2010; Sills and McKillop 2018). Mapping of wooden posts and associated artifacts on the sea floor, as well as excavations of some of the buildings, indicate they were salt kitchens where brine was boiled in pots over fires to make salt, a dietary requirement in demand at inland Maya cities. Salt was produced by surplus household production by families who stored this valuable commodity in the form of salt cakes and also transported them to marketplaces at inland communities in southern Belize (McKillop 2019; McKillop and Aoyama 2018a, b). This provides a model for other Maya salt works where wooden architecture, boats,

FIG. 2 *Map of the southern Belize research area, with insert map of its location in the Maya area. Map by Mary Lee Eggart, Louisiana State University.*

and canoe paddles are not preserved, indicating there was an infrastructure for the production and distribution of salt in the marketplace economy of the Classic Maya.

FIG. 3 *Snorkeling archaeologists on Research Flotation Devices (RFDs) in the lagoon, with inserts showing cut ends of wooden building posts. Photos by Heather McKillop.*

Methods For Sea-Floor survey

Most of the 110 sites that comprise the Paynes Creek Salt Works are located within a five sq km area and are underwater in Punta Ycacos Lagoon. Two sites consist of earthen mounds in the adjacent mangrove flats (Watson et al. 2013; Watson and McKillop 2019). The salt works were discovered during sea-floor survey. A site is defined as a cluster of pottery and wooden posts embedded in the sea floor and separated from other clusters by at least 10 m. The sites were discovered by systematic survey of the sea floor by a team of snorkeling archaeologists on RFDs (Research Flotation Devices), traversing the lagoon back and forth, shoulder to shoulder, looking for artifacts and posts protruding from the sea floor and feeling for them by hand (McKillop 2016). The locations of posts and artifacts were marked by survey flags that were labeled using numbers and letters, respectively (Figure 4). The diameter of each post was measured. Each item was mapped using a total station from permanent datums. The digital data were transferred to a laptop at the field camp and entered into a GIS (Figure 5). Maps were printed and enclosed in plastic to aid in the search of additional posts that formed missing corners of buildings, for example. The survey flags were removed at the end of each field season. In some cases, labeled survey flags were furled inside plastic straws and driven into the sea floor beside posts to help relocate posts in the case of additional field research.

The wooden posts define the outlines of rectangular buildings, with palmetto palm posts forming land-retaining walls along the edges

FIG. 4 *Survey flags marking the locations of wooden posts below the sea floor. Photo by Heather McKillop.*

FIG. 5 *Map of Site 74 showing location of wooden posts demarcating outlines of buildings. Map by Heather McKillop.*

of sites. The buildings were constructed on dry land, but were submerged by sea-level rise, as documented by red mangrove peat which forms the matrix of the sea floor (McKillop et al. 2010). The wood was preserved in the anaerobic conditions of the mangrove peat, which formed the ground when the buildings were constructed. Posts driven into the ground preserved, but the above-ground portion of posts decayed. A total of 4042 wooden posts and other architectural elements were mapped (McKillop 2019). Most were vertical posts. A minority of the mapped posts were horizontal palmetto or hardwood, but few were exposed for mapping since that subjected them to decay in the water. Wood for building construction and for fuel was selected from the nearby deciduous rainforest, mangrove ecosystem, and coastal woodland (Robinson and McKillop 2013, 2014).

Ethnographic Model of Salt Production

Salt production using brine from a salt spring at the modern Maya community of Sacapulas in the highlands of Guatemala was used as a model to evaluate the material evidence at the Paynes Creek Salt Works (Reina and Monaghen 1981). At Sacapulas, brine from

the salt spring is spread over the ground near the spring and then gathered and carried in a basket to a brine-leaching area. The soil is placed in an elevated wooden box with a hole in the base. Brine is poured on the salty soil, is sieved through a mat, and collected below in a large jar. The enriched brine is carried to a salt kitchen, where it is poured into a couple of dozen open bowls placed over a fire. The bowls are made by each family at their home and brought to the salt kitchen. Using a calabash gourd bowl, the brine is continuously refilled until the water is evaporated. In some cases, the salt-filled bowls are turned over and the wet salt is hardened on the fire. The pots are broken, leaving hard salt cakes. Sometimes the wet salt is made into other shapes using forms.

Each family has a salt kitchen used exclusively for salt production and related activities, including storing firewood, salt cakes, jars of brine and loose salt, and salty soil. The salt kitchens are located near the salt springs, with the houses located farther back. Working six days a week, production is about 56 kg/day, which amounts to about six tons over a 16-week dry season. During salt production, trips are made to other communities to sell salt cakes at markets, which sometimes requires overnight stays.

At Sacapulas, as well as other Maya highland salt works, such as San Mateo Ixtatan (Andrews 1983: 81-87), the salt pots are standardized in their dimensions in order to produce a standard-sized salt cake for marketplace trade. On Bohol Island in the Philippines, Yankowski (2010) describes standardized pots that are made by potters for the salt producers. The salt is hardened inside pottery jars, which are traded with parts of the base removed to expose the salt. Sometimes the salt pots are cut in half longitudinally, to trade as smaller standard units.

Salt Production at the Paynes Creek Salt Works

Several lines of evidence indicate Sacapulas provides a useful model for the Paynes Creek Salt Works. In both instances the brine is enriched before it is boiled in order to minimize the boiling time and to reduce wood fuel needs. The location of the Paynes Creek Salt Works along the shores of Punta Ycacos Lagoon provided natural solar evaporation of the shallow lagoon waters during the dry season, making the location more favorable than the open sea. The salt pots were made locally, as indicated by the recovery of a pottery paddle (Figure 6), the friable nature of the clay pots, and the availability of local sources of clay and quartz sand temper. The use of a wooden container to enrich the brine is evident at Site 67 (the Eleanor Betty site), where an old canoe was found preserved in thick silt between two lines of palmetto posts (McKillop 2017;

FIG. 6 *Wooden pottery paddle from Site 103, with jagged edge that protruded from the sea floor. Photo by Heather McKillop.*

McKillop et al. 2014). The canoe was supported by wooden stakes and had a large, clay funnel below. Funnels were commonly recovered at other sites, underscoring the practice of enriching the salinity of brine by pouring salty water on salty soil and collecting it below in pots before the brine was boiled (Figure 7).

FIG. 7 *Punta Ycacos Unslipped clay funnel, showing exterior (7a) and interior (7b). Photos by Heather McKillop.*

Elsewhere, piles of leached soil from the brine-enriching process are common on the landscape of salt works where brine boiling is used, including the Placencia Salt Works in Belize (Sills 2016, 2017) and the Pacific coast of Guatemala (Coe and Flannery 1967). Only two of the Paynes Creek Salt Works have earthen mounds, preserved in black mangroves along the shores of the lagoon (Watson and McKillop 2019; Watson et al. 2013). Trench excavations at Witz Naab and Killer Bee sites revealed soil with charcoal and fragmentary briquetage that was discarded from nearby salt kitchen boiling. Similar leaching mounds were probably common, but were deflated by sea-level rise and wave action. Modern patches of red mangroves at most of the submerged sites may be indicators of the location of relict earthen mounds. The mangroves may have developed on areas of high ground and therefore were not destroyed by rapid sea-level rise.

The mapped wooden posts defined the outlines of rectangular structures, with large-diameter posts at the corners and as supporting posts along the walls and interior (McKillop 2010b, 2019). Thinner posts may have been set on the ground surface to form the walls and provide an interior space protected from rain and wind for brine boiling and for storing salt cakes, pots of brine, and wood fuel.

Excavations of 10 structures revealed the artifacts were overwhelming related to salt production, consisting of 90-98% briquetage (McKillop and Sills 2016, 2017; Sills and McKillop 2018). Vessels were smooth on the interior and rough on the exterior, with thick rims and necks and thin bodies. Thin bodies conduct heat well, whereas rough vessel exteriors are suitable for lifting. The brine-boiling pots include jars, open bowls, and vertical-wall basins, which were supported by solid clay cylinders (Figure 8).

FIG. 8 *Briquetage-Punta Ycacos pottery type. a,b,e) jar exterior, profile, and interior; c) spacer profile and front views; d) cylinder and socket; f) clay cylinder; g) vertical wall basin; h) open bowl profile and interior. Photo by Heather McKillop.*

The clay cylinders had a socket at the top where the vessel rested. Spacers with two concave surfaces separated pots over the fire. Calabash bowls (Crescentia cujete) from the Stingray Lagoon and Eleanor Betty sites may have been used to pour brine into pots while they were on the fire in salt kitchens, as at Sacapulas. Two types of water jars were common, notably Mangrove Unslipped and Warrie Red (McKillop 2002). Both are calcite-tempered with smooth exteriors and interiors. Warrie Red often has distinctive "unit-stamped" decoration on the vessel shoulder, similar to pottery from inland sites in southern Belize and adjacent Guatemala. In fact, Warrie Red is an inland trade ware that serves as a proxy for the inland salt consumers of the Paynes Creek salt (McKillop, Howie, and Sills 2019). They were suitable for storing brine and loose salt produced from brine boiling (Figure 9).

FIG. 9 *Warrie Red "unit-stamped" jar from Site 7. Photo by Heather McKillop.*

Surplus Household Production

More than a dietary necessity, salt cakes were commodities suitable for storing at the salt works and trading at regional marketplaces. As standard units, salt cakes were good risk management to be stored and traded when the salt workers needed inland food or other resources or when the value for the standard units of exchange was more beneficial, such as during the rainy season. Although most production was likely in the dry season to take advantage of naturally salty lagoon water, storing enriched brine or salty soil, as at Sacapulas, made year-round salt production viable. The salt cakes were made by turning over the salt pots to harden the salt after the boiling process, or by forming wet salt into shapes and hardening the formed salt cakes. The pots may have been broken to remove the salt cakes, as at Sacapulas. Alternatively, the salt cakes may have been traded in pots, as at some salt works on Bohol Island in the Philippines, where pieces of the base of the pot

are removed but the pots are transported with the hardened salt inside (Yankowski 2010).

The salt pots and vessel supports from the three original sites discovered and excavated at the salt works, Stingray Lagoon, David Westby, and Orlando's site, were standardized in their dimensions, reflecting use of the pots to make uniform salt cakes (McKillop 2002: 127-134). There were statistically significant differences in the briquetage measurements from the three sites, suggesting separate work parties, or families worked at the salt kitchens at each of the three sites. Comparison of the types of wood used in building construction indicated that two of the sites, David Westby and Orlando's site, had similar patterns of tree species selection, perhaps due to sharing of these tasks or joint trips to procure construction materials. Stingray Lagoon site had a different pattern of tree species selection and dated later in time (McKillop 2019).

Marketplace trade

Marketplaces identified at Classic Maya cities including Tikal, Caracol, Buenavista, Calakmul, and Chunchucmil, underscore regular markets were held at communities both large and small during the Classic period and that this was a fundamental part of the economy. At Ceren, a small community dramatically preserved by a volcanic eruption in El Salvador, householders took surplus commodities to markets in several nearby communities (Sheets et al. 2015). A central plaza with stone stalls served as a permanent marketplace at Tikal (Jones 2015). Marketplaces at the ends of roadways at the Maya city of Caracol, Belize provided a venue for suburban Caracol Maya to obtain goods and resources from nearby and farther away, including obsidian and painted serving dishes (Chase et al. 2015). Spatial patterns delineated by soil chemistry and stone tool production debris in a central plaza at Buenavista in western Belize marked the locations of market stalls made from perishable materials (Cap 2015). Standard sizes of woven cotton and cacao beans served as currency equivalencies in marketplace trade, since the Maya did not have actual currency (Baron 2018). Salt cakes may also have served as standard units of exchange and also had the benefit of being a storable commodity (McKillop 2019).

Despite a virtual absence of fish bones at the Paynes Creek Salt Works, use-wear analysis of chert stone tools indicated that most were used for cutting fish or meat or for scaling fish or scraping hides (McKillop 2019; McKillop and Aoyama 2018a, b). A minority of the stone tools were used for wood working, which was surprising given the quantity of trees cut down, building posts sharpened to

drive into the ground, and other wood working. Salted fish provided an additional storable commodity produced at the salt works that like salt cakes, could be stored and traded according to the needs of the salt producers. The acidic mangrove peat that formed the matrix of the salt sites did not preserve bone, so any fish bones would not have preserved. However, at the nearby island trading port of Wild Cane Cay, abundant marine fish bones were preserved in waterlogged deposits (McKillop 2005b: 36-37).

The recovery of a full-sized, wooden canoe paddle from the K'ak'Naab' site, another paddle from Site 7, and parts of paddle blades from sites 74 and 83, as well as the canoe from the Eleanor Betty Site, indicate canoes were used and that there was an infrastructure of transportation at the salt works (Figure 10; McKillop 2010c, 2017; McKillop et al. 2014).

FIG. 10 *Warrie Red "unit-stamped" jar from Site 7. Photo by Heather McKillop.*

As at Sacapulas, the salt workers may have traveled on a regular basis to regional markets, including overnight stays. Some of the contingent activities, such as transporting salt cakes and other marine products to market, may have been farmed out to relatives, as reported for modern Maya pottery production in the Yucatan (Arnold 2017). Marine fish bones comprised 39% of the animal remains from Lubaantun, a site with unit-stamped and other pottery similar to the Paynes Creek Salt Works (McKillop 2002). In addition, the jacks (Caranx sp.), grouper (Serranidae), and snook (Centropomus sp.) identified at Lubaantun also were common in the Classic period middens at Wild Cane Cay dated to the same time (McKillop 2005b). Since Wild Cane Cay is a short canoe paddle distance from Punta Ycacos Lagoon, was a 10-acre village with a natural harbor, and had access to plentiful marine fish, the Paynes Creek salt workers may have salted fish caught by fisherfolk living at the island trading port. Some of the salt workers may have lived

on the island since their residences have not yet been identified at the salt works.

Supply and Demand of Dietary Salt in the Classic Maya Economy

Although the salt flats on the northern coast of the Yucatan were previously considered the suppliers of salt exported long distances to the southern Maya lowlands where the Classic Maya civilization developed between A.D. 300 and 900 (Andrews 1983), the discovery of salt works along the coast of Belize indicated they were closer sources of salt for the Classic inland Maya (McKillop 2002). Estimates of salt produced along the coast of Belize, at inland salt springs, and on the Pacific coast of Guatemala, indicate regional production and marketplace trade of salt is a viable model for satisfying the Classic Maya demand for dietary salt (McKillop 2019).

The amount of salt produced in a salt kitchen at Sacapulas can be used to estimate salt production. Salt production per salt kitchen at Sacapulas is 56.7 kg/day (Reina and Monaghen 1981), which would be 6 tons over the course of a four-month dry season, assuming salt workers produce salt six days/ week. Applying that production to the Paynes Creek Salt Works, one salt kitchen produced 6 tons over the course of a four-month dry season, whereas 100 salt kitchens produced 600 tons of salt (McKillop 2019; McKillop and Aoyama 2018). Some sites includes more than one salt kitchen, notably the Harry Gomez site and Ek Way Nal which each had 10 wooden buildings—although some buildings may have served other uses or may not have been used at the same time. Six other salt works along the coast of Belize also contributed to the supply of dietary salt to inland Maya, including Placencia (Sills 2016, 2017), Wits Cah Ak'al (Murata 2011), Moho Cay (McKillop 2019), Marco Gonzalez (Aimers et al. 2016), Northern River Lagoon (Mock 1994), Saktunja and other sites along lagoons in northern Belize (Masson and Mock 2004). Cerros also produced salt in the Preclassic (Robertson 2017). Adding production at inland salt springs, including Salinas de los Nueve Cerros (Woodfill et al. 2015), Sacapulas (Reina and Monaghen 1981), San Mateo Ixtatan (Andrews 1983), and Ixtapa (Andrews 1983), among others, indicates that a lot of salt was being produced near the core area of the Classic period civilization in the southern Maya lowlands.

Demand for dietary salt can be estimated based on daily needs that vary according to level of physical activity, climate, and salt appetite. Using an estimate of 6 g per day/person (Adshead 1992), one salt kitchen at the Paynes Creek Salt Works produced salt for 7087 people over the course of the four-month dry season. Twenty-

five salt kitchens in production would have supplied dietary salt for about 88,000 people (McKillop 2019; McKillop and Aoyama 2018). Population of inland Maya cities in southern Belize in the Classic was much lower, with small cities at Uxbenka, Lubaantun, Nim li punit, and Pusilha, as well as smaller communities. Even if half the salt was used to salt fish, there was significant dietary salt produced for local coastal use and for inland trade to meet consumer demand.

3D Technology for Preservation and Archaeological Tourism

Three-dimensional imaging of salt-waterlogged artifacts and architectural wood was used to provide a research-quality record of the finds, as well as to make 3D printed replicas for exhibits, outreach, and teaching. If we allowed the pottery to dry after we removed it from the sea, the salt came to the surface, expanding and cracking the object. If we allowed the wood to dry after removing it from the sea, the wood shrunk, destroying the surface and wood structure. Therefore, any pottery or wood of interest for study was kept in bags of water. Samples were cut from the tops of wooden building posts for species identification and carbon 14 dating. All wood samples were placed in labeled bags of water. They were exported wet, but with the water removed from the bags, to Louisiana State University for study. Some pottery was 3D imaged in the field at our base station. We used Next Engine Desktop surface scanners attached to laptops, with a gas-powered generator. The files were post-processed in the Digital Imaging and Visualization in Archaeology (DIVA) lab at Louisiana State University. Some artifacts were returned to the lagoon where they were stored in deep silt in designated cache locations. A minority of wooden objects, such as the K'ak'Naab' canoe paddle, were exported under temporary export permit from the government of Belize for conservation at the Texas A&M Preservation lab. The 3D surface scanning of the artifacts provided a record for study, since the original artifacts decayed out of water.

Permanent exhibits in the community of Punta Gorda, the capital of the Toledo District, near the Paynes Creek Salt Works were opened, along with lectures, and workshops. Site visits are rare due to the remote location and short duration of the field research (Figure 11). The intention of the exhibits and other outreach activities was to involve the local community in protection of the salt works by making them part of the local ecotourism economy. The Toledo Tour Guide Association suggested that if we put an exhibit at the Paynes Creek Ranger Station, people would need to hire them to travel to see the exhibit. This would enhance the tourism experien-

ce for visitors and put money in the pockets of the local marine tour guides.

We made 3D printed replicas of artifacts and wooden posts at LSU, and placed them inside locally-made display cases for the Tourism Information Center in Punta Gorda and the Ranger Station in Paynes Creek National Park (Figure 12). Laminated posters and information cards accompanied the exhibits. The opening of the exhibits in 2012 brought much local attention, along with broader knowledge through the Belize radio and television media. In 2013 we had a one-day showing of the original K'ak'Naab' canoe paddle in Punta Gorda before the conserved paddle was returned to the Belize Institute of Archaeology (Figure 13). This event, at which visitors were encouraged to hold the paddle and take photos, was well attended. An interview on Belize TV and radio broadcast the return of the canoe paddle widely known (Figure 14).

FIG. 11 *Classic Maya wooden canoe paddle from the K'ak'Naab' underwater salt work, with insert showing close-up of blade that is broken on one side. Photo by Heather McKillop.*

FIG. 12 *Exhibit in the Tourism Information Center in Punta Gorda featuring 3D printed replicas of artifacts and building posts, 2012. Photo By Jill Cotter.*

FIG. 13 *First public viewing of the K'ak'Naab' canoe paddle after conservation, Punta Gorda Tourism Information Center, 2013. Photo by Dorna Young.*

FIG. 14 *Showing the K'ak'Naab' canoe paddle on the Morning Show at LoveTV, 2013.*

It is at the Museum of Belize in Belize City. Subsequently, a new exhibit was opened in Punta Gorda featuring a 3D printed replica of the K'ak'Naab' canoe paddle inside a locally-made display case. The 3D replica was printed actual size at 143cm (4'7") of ABS+plastic on the Dimension Elite 3D printer in the DIVA Lab at LSU (Figure 15). The 3D printed replica is regarded as the real canoe paddle in the local community, since the paddle is an exact replica, it is in a display case, and it has a full-sized photo of the original paddle, along with another laminated information poster.

Workshops and lectures were carried out along with the opening of the exhibits of the 3D printed artifact replicas. Workshops with the local Maya craft group in Punta Gorda included laminated sheets with designs from artifacts from the Paynes Creek Salt Works (Figure 16). The sheets could be signed out so the women could take them to their villages and return them the next time they came to Punta Gorda. Rosewood carvers were not interested in a workshop. Public and school talks were well-received. Laminated posters about the permanent exhibits were distributed to hotels, restaurants, and stores in Punta Gorda. Although successful in the short term, the exhibits need regular attention due to staff turnover at the Tourism Information Center and other needs for space in the building. Outreach activities in Baton Rouge were well attended (Figure 17).

FIG. 15 *3D printed replica of the K'ak'Naab' canoe paddle in a display case at the Toledo Information Center. Photo by Heather McKillop.*

FIG. 16 *Maya artist at the Maya craft store in Punta Gorda, holding a laminated sheet with designs from Paynes Creek artifacts. Photo by Heather McKillop.*

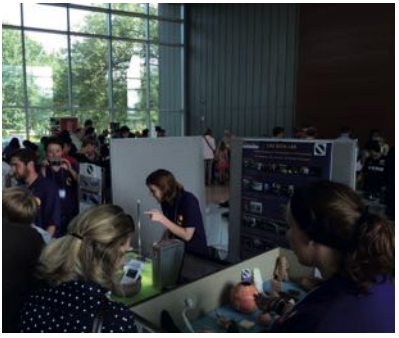

FIG. 17 *Exhibit featuring 3D printed replicas of Paynes Creek artifacts at the Maker-Faire, Baton Rouge Main Library, October 2015. Photo by Heather McKillop.*

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