# **Observations on the Heritage property, Point May, Burin Peninsula, Newfoundland**



Heritage property: location of float boulder with 8.2 g/t Au, 515 g/t Ag; looking 1 km NNE to Eagle zone drilling (red, upper left); float (inset) consists of finely crystalline quartz, with sulfides largely weathered

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#### **Summary and recommendations**

The Heritage property is located at the southwest end of the Burin peninsula, Newfoundland, near Point May. The host rocks to epithermal veins are units of the Neoproterozoic Marystown Group, and consist of mafic to felsic volcanic and volcaniclastic horizons, with both mafic and felsic dikes. The mafic dikes tend to follow mineralized structures in the Eagle zone, and appear to be late-mineral in timing, with altered contacts. These synhydrothermal mafic dikes are common in precious-metal epithermal systems with low sulfide content, consistent with the position of the Heritage property on the western margin of a volcanic arc, adjacent to sedimentary units that are related to a rift basin and which host similar epithermal veins to the northeast. After deposition of Cambrian sedimentary cover, the area was rotated ~20 to 45° to the northwest, with erosion now resulting in a rather flat terrain. Both magnetic and electrical surveys indicate a strong structural fabric, with NNE to NE-trending structures but also NW-oriented cross structures. It is possible that the property consists of several structural blocks with repetition of rotated stratigraphy and also offset along faults, i.e., different erosional levels of the epithermal veins.

The epithermal veins have several typical characteristics, including bands of adularia, fine to colloform banding, quartz pseudomorphs after bladed calcite and local bonanza grades of precious metals with silver sulfosalts (including naumannite, forming ginguro bands), all of which are consistent with episodes of sharp cooling due to vapor loss accompanying boiling. The overall sulfide content is low, with trace pyrite as well minor base metal sulfides, and the Ag:Au ratio is variable, from <10:1 to  $\geq$ 100:1, with some native silver present to kg/t concentrations, whereas the deportment of gold (locally to 10s g/t) is not known. Alteration is dominated by white mica, mainly illite and phengite, with chlorite at greater depth, possibly more abundant in the eastern (more deeply eroded?) area, with local % concentrations of Zn and Pb deposited in an early event. The mineralized veins are discontinuous and not well banded in zones up to ~10 m wide, although higher grades are focused in narrow zones of <1 m core width. Much of the quartz is finely crystalline to cryptocrystalline, making it difficult to judge a relative depth of formation across the area. There are high concentrations of Se, Sb, Mo, Sn, and variable As and Mn (locally low to high), and reports of minor Mn minerals. Many of these features may be due to multiple events of vein formation and brecciation.

Questions include: the source of volcanic products, particularly the block and ash flows, with direction and distance to volcanic center(s), and whether or not the veins are related to a volcanic center (e.g., flow dome); the relation of the different areas to one another, including level of erosion (simple SE deeper and NW shallow due to simple rotation, or multiple blocks with various levels of erosion of overall NW-tilting host rocks); the nature of the mineralized structures, and if they are largely NNE to NE, and their pre-rotation orientation and zones of opening (and mineralization); the explanation for variations in the nature of veins and geochemical anomalies across the area, due to different levels of erosion or in part due to multiple pulses of mineralization; the degree to which the magnetics reflect the areas of alteration, and whether or not high-resolution magnetics can trace the narrow mafic dikes that follow some of the vein structures; the cause of the linear chargeability anomalies in an overall low sulfide-content system – both veins and wallrocks – and the degree to which linear chargeability highs, like those in the Eagle zone, correlate with mineralized structures.

Based on the extent of mineralized boulders and their anomalous compositions, the degree of shallow cover, and the area of silicification of and quartz veinlets in volcanic rocks in outcrop, plus the consistent indications of geophysical signatures for major structures related to mineralized veins – particularly in the Eagle zone – and the grade intersections in drill core (up to >10 g/t Au equivalent), there appears to be several areas of untested potential on the Heritage property, initially in the Eagle zone vicinity, and on strike.

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## Recommendations

- Compile all work done to date, with a systematic organization of all data (float, channel and drill hole samples) and information (mapping and logging results with stratigraphy; geophysical surveys, etc.). Construct visual depictions of the data and information on maps and sections, to allow a critical assessment of the available data and information, in order to help provide targets to test with further drilling. Large format maps, with one transparent folia sheet per layer of information, will keep data compiled and help to cross-reference different data sets.
- Plot drill hole logs of lithology, alteration (including % pyrite), and veins plus grades on sections, and overlay on the induced polarization inversions, both chargeability and resistivity, in particular to determine what is causing the moderate chargeability high that is linear and oriented NE-SW in the Eagle zone (labeled zone A1 on the chargeability map), associated with a broad resistivity low that corresponds to the magnetic low, interpreted as being due to alteration. Examine the sulfides in the drill holes on IP section 3300 N, particularly at depth, to help interpret the chargeability anomaly that corresponds to the Eagle zone.
- Map lithologies in detail, with several SE to NW traverses along outcrops and, where available, with corresponding drill hole core to examine. Determine the stratigraphic sequence (with likelihood of lateral facies variations) and identify any marker horizons that may be correlated between portions of the prospect, in order to assess possible levels of preservation after tilting, as well as repetition due to the potential presence of different fault blocks. Along the rotational strike, NNE to WSW, is there a consistent change in indication of proximity to a volcanic center (or centers), or for offset (along faults, as suggested from the magnetic survey).
- Commission a structural study of veins and dikes, to determine how close the dikes follow vein structures, and whether there are significant changes in strike or dip that correlate with mineralized intervals, possibly shoots; is there evidence for offset of mineralized veins along faults. In conjuction with the mapping traverses, examine the nature of post-mineral rotation and the possibility for distinct fault-bounded blocks.
- Further geophysical surveys: Consider the use of a more detailed ground magnetic survey (e.g., 25-m lines in the Eagle area), to trace mafic dikes that have intruded along structures. Once an assessment of the chargeable highs has been completed, consider the use of extending the IP chargeability survey to the area west of Fishers Pond, as well as northeast of the Eagle zone (along with the ground magnetic survey).
- A focused alteration study of selected holes, shallow and deep along the Eagle trend, and between the two trends, west and east, may help to place constraints on the level of erosion after rotation.
- Examine the potential of the parallel chargeability high to the west (labeled zone F1) to reflect a mineralized vein similar to the Eagle zone. Consider testing this parallel linear chargeability high, with SW projection toward mineralized float. Keep in mind that if the same rotational block as the Eagle zone, for every 100 m NW, the equivalent vein level may be 50-100 m deeper.
- The area of the Eagle zone and its structural projections to the NE and SW are associated with a sizable magnetic low due to alteration, and has a strong structural preparation. Future drilling should step out and test the potential of these adjacent areas. The eastern structure, with an apparently narrow alteration extent (and possibly deeper level of erosion?), has a lower priority for now.
- Consider a geometallurgy study of Au and Ag recoveries by gravity and concentrate.

# Introduction

Mr. Victor French, President and COO of Puddle Pond Resources, Inc., requested the author to visit the Heritage epithermal property at the southern tip of the Burin Peninsula, Newfoundland, to comment on its assessment. One day was spent in the field and a second day examining drill core with French and two other company geologists, Tim Froud and Gregory Woodland. In addition, Greg Sparkes, Newfoundland and Labrador Department of Natural Resources, also joined the group. These people are thanked for their observations, discussion, comments and contributions, although the author is solely responsible for the conclusions presented in this report.

# Background

The Heritage gold-silver project is located in Avalon terrane, a belt of Neoproterozoic rocks that host a variety of epithermal deposits from the Carlolina Slate Belt (the Haile and Ridgeway low-sulfidation mines and the Brewer high-sulfidation mine, which produced  $\sim 2$ Moz gold between them) to Morocco (the huge Imiter silver-mercury mine; Fig. 1). The Avalon terrane in Newfoundland hosts the Hope Brook high-sulfidation deposit and mine ( $\sim 0.75$  Moz gold production), as well as numerous epithermal prospects on the Avalon and Burin peninsulas (Fig. 2). There are several areas of hypogene advanced argillic alteration and indications of high-sulfidation mineralization, such as at the Hickey's Pond and Monkstown Road prospects of the Burin peninsula (Fig. 2). The Stewart area of the Burin peninsula and the Opal Pit mine in the Avalon peninsula are both pyrophyllite dominant and appear to have been eroded to a sub-volcanic level. These prospects and their volcanic arc host have been tectonized and affected by greenschist-facies metamorphism. By contrast, distinctly different low-sulfidation vein prospects are present in both areas (e.g., Bergs, Steep Nap and Grog's Pond in the northern Avalon peninsula, and the Big Easy prospect north of the Burin peninsula as well as Long Harbor to the west). The Big Easy prospect is hosted by rocks that appear to be related to extension (O'Brien and King, 2002). Although not affected by metamorphism to the same degree as those in the arc, these prospects have been rotated.



Fig. 1. Reconstruction of the Neoproterozoic Avalonian terranes, which extend from Newfoundland to the southwest to the Carolina slate belt, and across the Atlantic to western Europe and the Anti Atlas of Morocco. Aside from high-sulfidation mines in the Carolinas, the most significant deposit in Newfoundland is Hope Brook, in a sliver of Avalon terrane in the southwest part of the island; the high-sulfidation deposit produced about 750 koz Au. From Kerr et al., 2005.



Fig. 2. Avalon terrane of the Burin peninsula, Newfoundland (O'Brien et al., 1999), showing the 595-575 Ma Marystown Group rocks (yellow) that comprise a volcano-plutonic arc. Arenaceous sedimentary rocks (brown), with bimodal volcanic products, of the Musgrave (in the north) and Long Harbor (to the west) groups constitute an extensional sequence (O'Brien and King, 2002). Hypogene advanced argillic alteration as well as high-sulfidation prospects occur in the Marystown Group arc rocks, whereas low-sulfidation vein prospects (e.g., Big Easy, noted as Henry's Pond in the north, and Heritage in the south) are confined to sedimentary rocks on the west margin of the arc.

The principle host rocks to advanced argillic alteration in the Burin penisula (Fig. 2) are the Marystown Group, consisting of felsic to mafic units of a Neoproterozoic volcanic arc. The Musgrave and Long Harbor rift-related sedimentary units occur adjacent to the arc; these rocks host the Big Easy (Henry's Pond) low-sulfidation prospect, an epithermal deposit ~200 km northeast of the Heritage project. Portions of the Marystown arc have been eroded below the epithermal environment, exposing granites at a plutonic level. The large variation in level of preservation, from the paleoground water table at Big Easy (siliceous lacustrine sediments) to sub-volcanic pyrophyllite alteration and quartz vein stockworks at Stewart through to large extents of granite outcrop indicate numerous tectonic blocks with variable tilting and erosion.



Fig. 3. Point May geological observations, based on 1:50,000 scale mapping (O'Brien et al., 1977), showing consistent NW dips (with a variable angle of 20 to  $45^{\circ}$ ) in both Marystown Group units as well as younger Cambrian sedimentary deposits to the northwest (Rencontre Fm). The Heritage project is centered around Fishers Pond. White scale bar = 5 km (base from Google Earth, 2014).

The Heritage project is located near Point May in the southern-most portion of the Burin peninsula, hosted by units of the Marystown Group, and overlain by Cambrian sedimentary rocks, all of which have been tilted to the NW, ~20 to 45° (Fig. 3; O'Brien et al., 1977). The Hare Hills Tuff, a sequence of felsic volcanic rocks, is present NW of the main prospect, whereas the underlying High Beach Basalt sequence hosts the epithermal veins and alteration. This unit is composed of lava flow and tuff members as well as sandstones and conglomerates (Fig. 3). Woodland (2015 presentation) notes that this basalt sequence has two members consisting of an andesite porphyry flow and a poorly sorted lithic tuff that hosts most of the alteration. The compositional variation of the High Beach mafic sequence may be consistent with a single sequence of volcanic events (G. Sparkes, pers. commun., 2016). Woodland (2015) notes that the mafic sequence has been affected by a regional low-grade green schist metamorphism, common in the Burin peninsula, which acted as an overprint of hydrothermal alteration at the Heritage property, including a broad propylitic halo.

The epithermal prospect was identified by prospectors in 2011 by tracing altered and quartzveined float to areas of outcrop and subcrop that are anomalous in gold and silver. The studies of glacial history indicate that the most recent ice movement (Wisconsinian maximum and late Wisconsinian recessional flow) was dominantly north to south in the Heritage area (Batterson et al., 2006).

The project was acquired by Puddle Pond Resources, Inc., in 2012, followed by sampling of glacial boulders, mapping of limited outcrop, and cutting trenches to bedrock beneath ~1 m

of till. By late 2012 the company had dug two-dozen trenches and collected over 600 channel samples that were cut in linear zones of silicified rock that were exposed. The best sample returned 13.1 g/t Au and 320 g/t Ag (31 October 2012 press release, Puddle Pond Resources) in the Eagle zone, a linear silicified zone ~1 km in length.

Two programs of ~2000 m drilling of shallow holes was conducted in 2013, with the best interval reporting ~5.5 m from 30 m drill depth at ~5.5 g/t Au and 133 g/t Au in HD-06 (Fig. 5; 6 December 2013 press release). The highest grades came from two intervals in HD-13 (a –45° hole), ~0.8 m at ~14.8 g/t Au and 574 g/t Ag at 83 m drill depth, plus ~0.4 m at ~34.9 g/t Au and 95 g/t Ag at 154 m drilled depth. A third drill program of 25 holes of ~3000 m on the Eagle zone, was conducted in 2015 (18 November 2015 press release). Notable drill intersections of ~0.7 to 1.4 m reported 1.4 to 1.9 g/t Au and 270 to 463 g/t Ag, as well as two 0.45-0.5 m intervals in HE-11 at 29 and 38 m of 16.4 g/t and 1322 g/t Ag, and 17.8 g/t Au and 704 g/t Ag. These results confirm earlier indications of silver-rich intervals, >100:1 Ag:Au. The highest grade silver value came from the re-assay of a 64 g/t Ag result for an interval with native silver, using an analytical technique to incorporate the content of metallic minerals that is not included in the preparation for ICP analysis.

The 2016 drill program (21 March 2016 press release) was underway during the author's visit, with limited assay results available (the first hole of the year, HE-26, on the Eagle zone, returned 6.5 m at 1.9 g/t Au and 258 g/t Ag). Drilling was largely conducted on the Eagle zone, with fill-in holes to allow a resource to be determined; deep drilling (HE-27) was also conducted at the Pinnacle zone (Fig. 7).



Fig. 4. View northeast to east (north end of Fishers Pond visible to right), with trenches visible at Ridge, Whales Back and other areas (right to left); two drill rigs (HE-40 and 42) are located on the Eagle zone (to left, red, drilling to southeast). Photograph taken near a recent float sample that returned 8.2 g/t Au and 515 g/t Ag (Fig. 7) on the high ground, ~20 m elevation above Fishers Pond.



Fig. 5. Plan map of the Eagle zone, showing the collars and traces of holes drilled in 2013 and 2015. Based on this drilling, the southwest-most hole with veins that reported grade was HE-18, with 0.6 m at 0.45 g/t Au and 132 g/t Ag. The northeast-most hole with reported grades was HD-08, with 7.7 m at 0.6 g/t Au and 63 g/t Ag (including 0.7 m at 1.4 g/t Au and 270 g/t Ag). Silicification trend noted in red (Woodland, 2015); other colors refer to High Beach mafic units. Grid lines = 200 m. Northern tip of Fishers Pond visible in the SW corner of the map.



Fig. 6. Results of induced polarization surveys conducted in 2014 and 2015. a) Chargeability, with two NE-SW oriented highs (one west of the trend that has been drill tested on the Eagle zone; Fig. 6,). b) Resistivity, with high resistivity to the east likely due to unaltered rock, and the low resistivity to the west, roughly coincident with the chargeability high, likely due to clay alteration (Diorio, 2014, 2015).



Fig. 7. Oblique Google Earth image looking north over part of the Heritage property, showing the location of Fishers and Long pond (scale bar = 500 m for the upper portion of the figure). The approximate location of drill collars of holes in the Eagle zone that returned mineralized vein intercepts is shown (red trend), ~600-m long and oriented NE-SW. To the SSW five holes were drilled toward the north end of Fishers Pond (orange trend; Fig. 4), with no significant values reported. Several of the areas with strong surface anomalies from channel samples (Fig. 8) are named, with the scars left from reclaimed trenches visible in several cases. A recently analyzed float sample adjacent to the access road is located NW of Fishers Pond, up slope at ~20 m higher elevation.

An induced polarization survey of chargeability/resistivity was conducted in 2014 of ~10-line km, over the Eagle zone and its extensions, and this was enlarged in 2015 with a further ~10-line km survey (100 m E-W line, 25 m dipole-dipole spacing), from ~5195700 m to 5197200 m N (Fig. 6; Diorio, 2014, 2015). Two linear anomalies of high chargeability (up to ~13 mV/V) are oriented ~NE-SW, located in the Eagle zone, possibly due to disseminated sulfides (pyrite) in the altered halos to quartz veins. Other irregular chargeable high anomalies are present in the north portion of the survey area, mostly associated with magnetic highs (see below). A high resistivity anomaly, east of the Eagle zone, is likely due to unaltered rock, whereas there is a broad low resistivity anomaly in the Eagle zone, likely due to clay alteration (Diorio, 2015); both of these indications are consistent with the results from the magnetic survey (below).

A high-resolution ground magnetic survey was conducted in the 2nd Q of 2016, with 41 lines spaced at ~100 m and a total of 74.5 km of continuous readings; the magnetic gradient was about 2150 gammas (Fig. 8; Fraser, 2016). Fraser (2016) interpreted major structures from the total magnetic intensity image (TMI, Fig. 8b), identified a major NNE trend that is associated with many of the surface anomalies of gold, and overlaid these structures on the chargeability results (Fig. 9).



Fig. 8. Results of a ground magnetic survey. a) Reduced to pole (RTP). b) Total magnetic intensity (TMI) with structural interpretation (Fraser, 2016). Eagle zone (white oval) lies within a 300-500 m-wide NE-trending alteration anomaly, parallel to but between two interpreted NE-SW structures. A second trend, ~NNE, extends from Whales Back to Pinnacle, east of Fishers Pond. Geochemical anomalies noted with red stars.



Fig. 9. Interpretation of magnetic survey (Fraser, 2016), with an overlay of the IP chargeability (high values match alteration zone). Major fractures, purple; NE-SW corridor of alteration (magnetite destruction), red: mafic dikes along east margin, green; area of unaltered mafic rocks (stippled, in the NE). Mineralized portion of Eagle zone (HD-08 SW to HE-15; white oval) corresponds to a linear chargeability high. A sub-parallel chargeability high (yellow oval) lies ~100 m to the west, inside the western structure, and extends to the SW.

## **Observations**

#### Surface

The rock units observed at surface, as float boulders and in trenches with cut channels, have mafic to felsic compositions and variable volcanic to volcaniclastic lithologies. The rocks range from crystal tuffs (Fig. 10a) to lapilli tuffs, the latter with monomict to polymict lithics; there are some horizons that have textures indicating epiclastic reworking. Some crystal-rich rocks are difficult to whether they are crystal tuffs or coherent lava flows; float of quartz-phyric rhyolite is cut by quartz veins (Fig. 10b), indicating that the Hair Hill Tuff may also be a host unit. A notable feature is the presence of block and ash flows, both monomict to polymict. This lithology is observed in outcrop in the Cabin and Zaxis-Tola zones (Fig. 10c, d), northeast of the Eagle zone (Fig. 9). To the east at the Flat Bed and Ridge areas (Fig. 9), block and ash textures are abundant in outcrop (Fig. 11), with monomictic as well as polymictic occurrences, including clasts of tuff and flow-banded blocks and epiclastic blocks. Block and ash textures may be more common to the east of the Eagle zone, i.e., deeper in the stratigraphy if there is a simple NW rotation of a single block. The lithologic variation across the Heritage area suggests a proximal position relative to one or more eruptive centers, possibly a flow-dome with sharp facies variations, both lateral as well as vertical.

Vein textures exposed at the surface have a wide variety of characteristics, from silicified zones with brecciation and cryptocrystalline cement, as at the Eagle zone discovery outcrop (Fig. 12) to veinlets (Fig. 10) and stockworks as well as chalcedony-cemented breccias and cross-cutting vein sets (Fig. 13).



Fig. 10. NE Eagle to Cabin and Zaxis-Tola areas. a) Plagioclase-phyric tuff, strongly silicified adjacent to veinlets. b) Rhyolitic unit (quartz phenocrysts in a spherultic matrix), cut by finely banded and brecciated veinlets, suggesting that the Hare Hill Tuff may also be a host to veins. c) Block and ash flow with monomictic blocks of plagioclase-phyric tuff. d) Block and ash tuff with nearby lapilli tuff, sharp facies variation. Some blocks may have (weathered) flow-banded textures, possibly due to a flow-dome origin.

There is a wide range of vein and brecciation textures in outcrop across the prospect, without any apparent consistent trend, despite the observations along >2.5 km of ~NE-SW structural trends across a width of up to 1.5 km (Fig. 9), with a general rotation to the NW of ~30°. Epithermal features are common, including the presence of adularia (Fig. 14e), quartz pseudomorphs after bladed calcite (Fig. 14a, c, f), colloform bands (Fig. 14d) and open-space fill textures (Fig. 14a, b), including sedimentary infill (Fig. 14b).



Fig. 11. Variable block and ash flows on the eastern trend. Flat Bed area. a) Polymict block and ash with clast of epiclastic material, cut by veins. b) Block and ash with flow-banded clast (left), massive coherent clast (lower left from center) and crystal tuff clasts, cut by minor veinlets. Ridge area. c) Polymictic block and ash flow, with angular to rounded clasts (xenolith rich). d) Monomictic block and ash flow, with deformed block (feathery tip, to right), indicating that the clast was sufficiently hot to be plastic once incorporated in the flow deposit.



Fig. 12. a) Discovery outcrop of the Eagle zone, looking north to the drill rig of HE-42; channels reportedly returned  $\sim$ 1-2 g/t Au and  $\sim$ 100-300 g/t Ag. b) Cryptocrystalline quartz with fine sulfides, partially weathered.



Fig. 13. View to the SSW (Long Pond), Fishers Pond (central), and drill rig set up on the Eagle zone (SW ~1.2 km, to right), from channeled outcrop at Whales Back. b) Network of irregular veinlets, with offset due to shearing, and carbonate weathered out. c) Early cryptocrystalline quartz, cross-cut by banded quartz veinlets. Flat Bed, channels reportedly with ~0.1 g/t Au (up to 0.3 g/t). d) Early banded quartz vein, offset and cut by veinlet of quartz with centerline open space. e) Early SW veinlet set cross-cut by larger SE-trending vein, reportedly up to ~0.3 g/t Au.

These features consistent are with boiling and vapor loss (adularia, bladed calcite, colloform bands of colloidal silica) as well as relatively shallow depths (open-space fill and sedimentary

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infill). Compared to the vein textures observed in the Eagle zone to the west, the features in the east are more typical of the epithermal environment. This raises the question of the relationship between the two NE to NNE-oriented trends on the property, west and east (Fig. 9), since a NW rotation should result in the erosion level to the east being deeper. Despite this, there are textures that indicate an epithermal level of exposure, and locally (but inconsistently), there are bonanza grades of gold at the surface. These observations suggest that there may be multiple rotated blocks across the property, east to west (Fig. 15).



Fig. 14. Surface vein textures, eastern trend. Turpin zone. a) Coarse bladed carbonate, pseudomorphed by quartz in brecciated rock with chalcedony infill (7.1 g/t Au); open-space fill with crystalline quartz. b) Open-space fill by crystalline quartz, plus detrital material (pointer) covered by finely laminated clays. c) Lunch Spot zone, reportedly ~13 g/t Au in trench; brecciated clasts (upper left) with quartz fill, bladed carbonate pseudomorph textures (pointer). Pinnacle zone, reportedly ~0.1-0.4 g/t Au. d) Clasts with fine banding, colloform textures (lower right); up to 1.5 g/t in channel, cryptocrystalline quartz cement. e) Adularia band with colloform overgrowth at base, late cryptocrystalline quartz. f) Fine acicular carbonate in cryptocrystalline quartz.



Fig. 15. a) WSW to WNW from Ridge zone outcrop to Eagle trend (right of center, with drill rig at HE-42, above pond, ~1 km away). The ridge on skyline to left consists of High Beach mafic outcrops of tuffs and lava flows; hills to right are flow-banded rhyolites and rhyolitic tuffs of the Hair Hill Tuff. Float on road, upper far left, below horizon, returned an assay of 8.2 g/t Au and 515 g/t Ag. Channel in foreground reportedly returned <50 ppb Au. Next zone to south, Turpin, reported ~7 g/t Au in a chip sample, the discovery outcrop of the property (Fig. 14a). b) Roadside showing, ~4 km south of the Whales Back showing, and ~1.5 km SSE of the Pinnacle zone (Fig. 9). Outcrop of silicified rock with chlorite, local brecciation and quartz veinlets, with reportedly  $\leq$ 20 ppb Au.

# Drill core

To date drilling has been largely conducted on the Eagle zone, as well as fewer holes at Pinnacle (Fig. 7). Results for many of the holes drilled in 2016 were pending at the time of writing this report.

Unlike many epithermal veins, much of the quartz in veins at the Heritage project is finely crystalline to cryptocrystalline (Fig. 16), without strong banding; however, there are local zones with fine laminations of quartz ± adularia, although these are indications of grade development (e.g., Fig. 17b). Although bladed textures (quartz pseudomorphs after bladed calcite, the latter consistent with boiling) are present at the surface, locally associated with good grades (e.g., Fig. 14a), their presence in drill core is not necessarily associated with mineralization, particularly in the Pinnacle zone to the southeast on the eastern structural trend (Fig. 20c).

Rather, the presence of silver sulfosalts, including acanthite  $(Ag_2S)$ , aguilarite  $(Ag_4SeS)$  and naumannite  $(Ag_2Se; Woodland, 2015)$  - locally with a dendritic behavior (Figs. 16b and 17a) – is indicative of good silver as well as gold results (i.e., Fig. 18, top). These dark silver sulfosalts are known as ginguro (Japanese for silver black), and can be associated with bonanza grades of precious metals, both silver and gold.

Veins and veinlets are developed in zones with drill core widths up to 10 m or more (Fig. 19), although the best grades are commonly in narrower zones, as narrow as  $\leq 0.5$  m. In HE-11 (Fig. 19c), 9.95 m starts at 28.9 m drill depth with 3.4 g/t Au and >161 g/t Ag (to be adjusted for the analysis of native silver), but there are narrow intervals of 0.45 m with 16.5 g/t Au and 1322 g/t Ag (a re-assay for metallic native silver, whereas the initial analysis by ICP reported 65 g/t Ag), and 0.5 m at 17.8 g/t Au and 704 g/t Ag. The contribution of high grades from narrow intervals in wider vein zones is common in epithermal veins, and reflects the multiple stages of mineralization that occurs, with only a portion of a vein structure being open to hydrothermal fluid flow at a given time.

Another feature of many vein intersections in the Eagle zone is the occurrence of mafic dikes on the HW and/or FW of the vein structure (Fig. 19). The dikes typically right on the contact of the vein structure with the wallrock (Fig. 19b). The dikes are not cut by quartz veins,



Fig. 16. a) HD-6, Eagle discovery hole, with 35.6 m at 1.25 g/t Au and 58 g/t Ag from 3 m depth (including 0.5 m at 4.6 g/t Au and 327 g/t Ag, and 5.5 m at 5.5 g/t Au and 133 g/t Ag. 29.9 m, massive silicification, cut by several stages of fine veinlets of cryptocrystalline quartz, and later siderite. b) HE-40-17 m, massive quartz vein, cryptocrystalline with chlorite, and dendrite sulfides, likely Ag sulfosalts (assays pending); see Fig. 17a.

indicating that the veins formed before the dikes. However, the magnetic dikes have altered, non-magnetic margins (~0.5 to 1 m wide; Fig. 19b), and can be cross-cut by calcite veinlets, as well as by sedimentary infill of fractures (Fig. 19c) of Cambrian age (G. Sparkes, pers. commun., 2016). These observations suggest that the mafic dikes may be late hydrothermal, after quartz vein formation but while hydrothermal activity was still present to alter the dike margins. If so, this is consistent with the common presence of syn- to late-hydrothermal mafic dikes in epithermal deposits with a low sulfide content and formed in zones of extension (Sillitoe and Hedenquist, 2003).



Fig. 17. a) HE-11, 10 m at 3.4 g/t Au and 161 g/t Ag from 29 m. 28.9 m, massive cryptocrystalline quartz vein with chlorite and patches of Ag sulfosalts; 0.45 m at 15.8 g/t Au and 65 g/t Ag; reassayed for metallics, with 16.4 g/t Au and 1322 g/t Ag. b) HD-8, 7.7 m at 0.6 g/t Au and 64 g/t Ag; well-developed adularia bands at 22.5 m in finely crystalline quartz veins; low-grade interval.



Fig. 18. HE-38-29.5, 32.5 m (top, assays pending) and HE-25-95 m (bottom, 1 g/t Au, 28 g/t Ag); HE-25 (Fig. 5) is located ~50 m south of HE-38. HE-38 interval, finely crystalline quartz veins with green illite (2218 nm phengite at ~34 m), and bands of Ag sulfosalts. HE-25, contorted quartz veins, chlorite alteration, no apparent Ag sulfosalts. Are the two holes offset by a fault, or is the Ag sulfosalt zone due to a steeply plunging shoot?



Fig. 19. Eagle zone. a) NW-SE section through HE-11, 19 and 20, with part of HD-12 beneath. High-grade vein margins of HE-11, HW and FW, were intruded by a mafic dike (blue). b) HW contact of vein in HE-11, showing a block and ash flow host to the quartz vein, intruded by a mafic dike at the contact at ~25 m (~3 m drill width, with central zone magnetic); dike margins demagnetized, suggesting a late-hydrothermal timing. c) HE-11, ~22 to 49 m, with 9.95 m from 28.9 m depth reporting 3.4 g/t Au and 161 g/t Ag (before re-assay of one 0.45 m interval with 1322 g/t Ag rather than 65 g/t). Mafic dikes are present on both HW and FW, magnetic except for margins (photograph in b shows a close-up of lower left corner). Magnetic susceptibility of the mafic dikes in several drill holes ranges from ~36 to 45 nT, with dikes near contact zones ~1 nT; wallrock is ~0.5 nT, and veins are ~0.2 nT. Note calcite veins cutting dikes, and late sedimentary fill of a fracture in the FW dike.



Fig. 20. Pinnacle zone. a) HE-27, 259.5 and 261.9 m, 0.11/0.23 g/t Au, 6.7/7.0 g/t Ag, 0.5% Pb, 1.4/7.5% Zn (W>440 ppm, ≤43 ppm Sn, ≤40 ppm Se, with low As, <160 ppm, <5 ppm Sb, <6 ppm Mo, <700 ppm Mn, <700 ppm Cu). b) HE-27, 219 m, 0.06 g/t Au, 6 g/t Ag; quartz vein with chlorite bands followed by greenish gel, minor sulfides. c) HD-1, 74.6 and 78.7 m, 0.1 g/t Au, 7 g/t Ag, <200 ppm Pb+Zn. Bladed textures in quartz vein, with clots of chlorite, and adularia replacement of wallrock, cut by late quartz veinlets.

The veins along the eastern trend, from Whales Back through Turpin to Pinnacle (Fig. 9) and beyond (Fig. 15b), are typically low grade in outcrop (Fig. 13), but locally report high grades,  $\sim$ 7 g/t in the Turpin showing and  $\sim$ 13 g/t for the Lunch Spot showing (Fig. 9). To date drilling on the Pinnacle zone (up to 5 g/t reported for a channel sample) has not repeated the surface results, with one 0.3 m interval with 2.4 g/t Au and 23 g/t Ag in HD-1 at 58.5 m depth; most results are up to <0.1 g/t Au and <6 g/t Ag. However, a deep drill hole, HE-27, intersected at ~260 m drill depth (~185 m vertical) cut a fracture zone with 1.4 and 7.5 wt% Zn and 0.5 wt% Pb, with 0.1-0.2 g/t Au and 7 g/t Ag. This Zn-Pb mineralization appears to be early, since it was cut by multiple episodes of subsequent quartz veins (Fig. 20a). Deep quartz veins in this hole (Fig. 20b) is finely crystalline and associated with chlorite, but is also low grade in precious metals.

# Discussion

The relatively high Ag:Au ratio of high-grade intervals, particularly in the Eagle zone, is due to the presence of Ag sulfosalts, as clusters (Figs. 16b, 17a, 18 top) and in ginguro bands (Fig. 16a). A plot of silver (by ICP) vs gold (by fire assay) (Fig. 21) indicates one trend of ~100:1, which is relatively high for a relatively sulfide-poor epithermal vein (more typically <10 or 20:1; Sillitoe and Hedenquist, 2003). There are commonly associations with Se due to the presence of naumannite. A few samples present native silver that is not recorded by the sample preparation for ICP analysis; one sample with 65 ppm Ag was re-assayed for metallics and returned a value of 1322 ppm (Figs. 21, 22b). By contrast, the results for gold were repeated from fire assay within reason (Fig. 22a).

To date, the observation of visible gold has been rare, despite grades locally in excess of 10 g/t. Although pyrite is reported to be As-poor, Woodland (2015) has noted the presence of sulfide mineral inclusions in pyrite near crystal margins, including the silver sulfosalts acanthite, aguilarite and naumannite. Interestingly, both acanthite and aguilarite are low-temperature forms, and all the reported sulfosalts indicate a S-deficient system. Without the observation of native gold, it is possible that gold is also present as inclusions on the margins of pyrite. A determination of the gold recovery from a gravity process versus that of a sulfide concentration would provide an indication of the deportment of gold in samples.



Fig. 21. Plot of notable Au vs Ag results from intervals in 25 drill holes from the Eagle zone (2015), with trends for 10:1 and 100:1 Ag:Au ratios. One sample with visible native silver was re-assayed for metallics, as this would not be included in standard sample preparation for ICP analysis; the result was over 20x higher in silver. The wide range in Ag:Au ratio for drill core samples unaffected by weathering may indicate multiple phases of mineralization. b) c) Results for metallic gold and silver versus Au by fire assay and Ag by ICP.

(mV/V)

The mineralized trend of the Eagle zone, ~600 m north of Fishers Pond (Fig. 4), lies between two NNE to NE structures, with NW-oriented structures proposed by Fraser (2016) at the NE and SW extent of this mineralized trend (Fig. 8), based on ground magnetic anomalies. Chargeability trends (to a moderate level of ~13 mV/V) are linear in the Eagle zone, with one high trend associated with the Eagle zone (Fig. 9). IP section line 3300N (Fig. 22) shows the location of the two linear trends, with NW-SE and SE-NW drill hole traces from ~50 m north and south projected onto the W-E section. The drill holes correlate to the chargeability high, with the best grades located at depths near the top of the high zone (at ~7 mV/V). The reason for this chargeability anomaly is not clear, as the wallrock sulfides are not in particularly high would help to interpret the chargeability anomaly.

In addition, consider testing the parallel linear chargeability high to the west, with a SW projection toward the mineralized float (Fig. 9). The irregular chargeability highs to the northeast, in the Cabin and Tola zone, do not correlate with the area of alteration indicated by demagnitization (Fig. 8b). Thus the significance of these chargeable zones is less clear than that of the clear linear anomaly that is parallel to and west of the Eagle anomaly.



The Heritage prospect sits on the west margin of the arc, close to or within the belt that O'Brien and King (2002) interpreted to be a rift. An occurrence of the Rencontre Fm is present just west of Heritage (Fig. 3), a sedimentary unit that is similar to the rift sequence west of the arc to the north (Fig. 2). Such a rift setting and associated extension may be consistent with the late-mineral basalt dikes on the margins of the vein-associated structures.

The Heritage deposit shares several characteristics with the Big Easy prospect, located ~200 km to the northeast in the Burin zone. Both epithermal vein systems have local enrichments of gold and silver, a high Ag:Au ratio, low sulfide content, and structural complexity with post-mineral tilting to the west. A major difference is that a portion of the Big Easy prospect likely has a more shallow level of erosion, with the deformed lacustrine siliceous sediments.

There were no indications of paleosurface or paleoground watertable seen at Heritage. However, there are finely crystalline to cryptocrystalline quartz textures in samples from both trends, west (Eagle) and east (Whales Back to Pinnacle), suggesting rapid deposition of silica, enhanced by the lower temperatures encounters at shallower depths. In addition, there is the local infill of open spaces with grading to fine clay laminae; this and other open-space textures are more characteristic of shallow depths.

Much of the alteration mineralogy proximal to veins in the Eagle zone is dominated by illite, although phengite is also reported (G. Sparkes, pers. commun., 2016). Smectite,

Epidote Biotite

Adularia

Mordenite

Laumontite Wairakite

Calcite

Alkaline

characteristic of lower paleo temperature and thus shallow depth (formed at <150 °C, i.e., within ~50 m of the paleosurface; Fig. 23), is not common in the Eagle zone, suggesting that this level has been eroded. Illite forms at >200-225 °C (Fig. 23b; i.e., equivalent to depth below the paleowater table of ~150-250 m; Fig. 23a). (Fig. 24), indicating that there was likely  $\sim$ 150+ m of erosion below the paleowater table.

The base metal mineralization at Pinnacle, at a vertical depth of 185 m (Fig. 20a) has been cut by later quartz veins. This and the variation in geochemical signatures (locally elevated Se, Sb and Sn as well as Mo – to 100s - 500 ppm – although in places these elements are not anomalous) may indicate multiple pulses of mineralization. In the Eagle Zone, base metalrich zones are uncommon, but may be found at greater depths. West and NW of the Eagle zone, in the direction of the rotation downward, more shallow levels may be encountered; the zone of potential mineralization may be encountered at greater depths than at the Eagle zone.



of the system (right) is more compressed toward the surface, whereas the lower temperatures on the margins of the system result in wider intervals of lowtemperature (e.g., smectite) clays. b) Ranges of temperature stability for typical epithermal minerals, both neutraland acid-pH stable, based on measurements in active geothermal systems (Hedenquist et al., 2000).

m 0

400 100

Epithermal ore deposition



Fig. 24. North-south cross-section through the Broadlands-Ohaaki geothermal system, New Zealand, showing the measured isotherms (with boiling upflow in wells 3, 18, 11, 2), and the alteration mineralogy (Simmons and Browne, 2000). Illite forms at >200°C and its distribution reflects the hot upflow. Adularia also reflects the zone of boiling upflow, since boiling and  $CO_2$  loss causes illite stability to shift to that of adularia (e.g., Illite + 6 SiO<sub>2</sub> + 2 K<sup>+</sup> = 3 Adularia + 2 H<sup>+</sup>).

The erosion level in the Eagle zone, indicated by the abundance of illite and adularia and paucity of smectite, may be similar to that indicated with most shallow position of the yellow line, with post-mineral rotation causing deeper levels to the SE; if so, this may be a possible schematic indication of the present erosion level. Another factor to consider is whether the whole prospect has acted as one block, or if there are several tilted blocks (i.e., with shallow levels exposed to the NW and deeper levels to the SE within a single block).



Fig. 25. Range of depths to top of Au zone, and vertical extent of ore, for different styles of epithermal deposits (Hedenquist et al., 2000). Low-sulfidation deposits, typically formed in extensional settings, have a vertical interval of ~100-200 m and form at relatively shallow (<300 m) depths; intermediate-sulfidation veins can have a larger vertical interval with top deeper below the paleoground watertable. Based on alteration mineralogy (and quartz textures), the depth of erosion (in the Eagle zone), may be ~150+ m (green line).

## **Summary and conclusions**

The Heritage property is located at the southwest end of the Burin peninsula, Newfoundland, near Point May. The host rocks to epithermal veins are units of the Neoproterozoic Marystown Group, and consist of mafic to felsic volcanic and volcaniclastic horizons, with both mafic and felsic dikes. The mafic dikes tend to follow mineralized structures in the Eagle zone, and appear to be late-mineral in timing, with altered contacts. These synhydrothermal mafic dikes are common in precious-metal epithermal systems with low sulfide content, consistent with the position of the Heritage property on the western margin of a volcanic arc, adjacent to sedimentary units that are related to a rift basin and which host similar epithermal veins to the northeast. After deposition of Cambrian sedimentary cover, the area was rotated ~20 to 45° to the northwest, with erosion now resulting in a rather flat terrain. Both magnetic and electrical surveys indicate a strong structural fabric, with NNE to NE-trending structures but also NW-oriented cross structures. It is possible that the property consists of several structural blocks with repetition of rotated stratigraphy and also offset along faults, i.e., different erosional levels of the epithermal veins.

The epithermal veins have several typical characteristics, including bands of adularia, fine to colloform banding, quartz pseudomorphs after bladed calcite and local bonanza grades of precious metals with silver sulfosalts (including naumannite, forming ginguro bands), all of which are consistent with episodes of sharp cooling due to vapor loss accompanying boiling. The overall sulfide content is low, with trace pyrite as well minor base metal sulfides, and the Ag:Au ratio is variable, from <10:1 to  $\geq$ 100:1, with some native silver present to kg/t concentrations, whereas the deportment of gold (locally to 10s g/t) is not known. Alteration is dominated by white mica, mainly illite and phengite, with chlorite at greater depth, possibly more abundant in the eastern (more deeply eroded?) area, with local % concentrations of Zn and Pb deposited in an early event. The mineralized veins are discontinuous and not well banded in zones up to ~10 m wide, although higher grades are focused in narrow zones of <1 m core width. Much of the quartz is finely crystalline to cryptocrystalline, making it difficult to judge a relative depth of formation across the area. There are high concentrations of Se, Sb, Mo, Sn, and variable As and Mn (locally low to high), and reports of minor Mn minerals. Many of these features may be due to multiple events of vein formation and brecciation.

Questions include: the source of volcanic products, particularly the block and ash flows, with direction and distance to volcanic center(s), and whether or not the veins are related to a volcanic center (e.g., flow dome); the relation of the different areas to one another, including level of erosion (simple SE deeper and NW shallow due to simple rotation, or multiple blocks with various levels of erosion of overall NW-tilting host rocks); the nature of the mineralized structures, and if they are largely NNE to NE, and their pre-rotation orientation and zones of opening (and mineralization); the explanation for variations in the nature of veins and geochemical anomalies across the area, due to different levels of erosion or in part due to multiple pulses of mineralization; the degree to which the magnetics reflect the areas of alteration, and whether or not high-resolution magnetics can trace the narrow mafic dikes that follow some of the vein structures; the cause of the linear chargeability anomalies in an overall low sulfide-content system – both veins and wallrocks – and the degree to which linear chargeability highs, like those in the Eagle zone, correlate with mineralized structures.

Based on the extent of mineralized boulders and their anomalous compositions, the degree of shallow cover, and the area of silicification of and quartz veinlets in volcanic rocks in outcrop, plus the consistent indications of geophysical signatures for major structures related to mineralized veins – particularly in the Eagle zone – and the grade intersections in drill core (up to >10 g/t Au equivalent), there appears to be several areas of untested potential on the Heritage property, initially in the Eagle zone vicinity, and on strike.

# Recommendations

- 1. Compile all work done to date, with a systematic organization of all data (float, channel and drill hole samples) and information (mapping and logging results with stratigraphy; geophysical surveys, etc.). Construct visual depictions of the data and information on maps and sections, to allow a critical assessment of the available data and information, in order to help provide targets to test with further drilling. Large format maps, with one transparent folia sheet per layer of information, will keep data compiled and help to cross-reference different data sets.
- 2. Plot drill hole logs of lithology, alteration (including % pyrite), and veins plus grades on sections, and overlay on the induced polarization inversions, both chargeability and resistivity, in particular to determine what is causing the moderate chargeability high that is linear and oriented NE-SW in the Eagle zone (labeled zone A1 on the chargeability map), associated with a broad resistivity low that corresponds to the magnetic low, interpreted as being due to alteration. Examine the sulfides in the drill holes on IP section 3300 N, particularly at depth, to help interpret the chargeability anomaly that corresponds to the Eagle zone.
- 3. Map lithologies in detail, with several SE to NW traverses along outcrops and, where available, with corresponding drill hole core to examine. Determine the stratigraphic sequence (with likelihood of lateral facies variations) and identify any marker horizons that may be correlated between portions of the prospect, in order to assess possible levels of preservation after tilting, as well as repetition due to the potential presence of different fault blocks. Along the rotational strike, NNE to WSW, is there a consistent change in indication of proximity to a volcanic center (or centers), or for offset (along faults, as suggested from the magnetic survey).
- 4. Commission a structural study of veins and dikes, to determine how close the dikes follow vein structures, and whether there are significant changes in strike or dip that correlate with mineralized intervals, possibly shoots; is there evidence for offset of mineralized veins along faults. In conjuction with the mapping traverses, examine the nature of post-mineral rotation and the possibility for distinct fault-bounded blocks.
- 5. Further geophysical surveys: Consider the use of a more detailed ground magnetic survey (e.g., 25-m lines in the Eagle area), to trace mafic dikes that have intruded along structures. Once an assessment of the chargeable highs has been completed, consider the use of extending the IP chargeability survey to the area west of Fishers Pond, as well as northeast of the Eagle zone (along with the ground magnetic survey).
- 6. A focused alteration study of selected holes, shallow and deep along the Eagle trend, and between the two trends, west and east, may help to place constraints on the level of erosion after rotation.
- 7. Examine the potential of the parallel chargeability high to the west (labeled zone F1) to reflect a mineralized vein similar to the Eagle zone. Consider testing this parallel linear chargeability high, with SW projection toward mineralized float. Keep in mind that if the same rotational block as the Eagle zone, for every 100 m NW, the equivalent vein level may be 50-100 m deeper.
- 8. The area of the Eagle zone and its structural projections to the NE and SW are associated with a sizable magnetic low due to alteration, and has a strong structural preparation. Future drilling should step out and test the potential of these adjacent and on-strike areas. The eastern structure, with an apparently narrow alteration extent (and possibly deeper level of erosion?), has a lower priority for now.
- 9. Consider a geometallurgy study of Au and Ag recoveries by gravity and concentrate.

# Qualifications

I, Jeffrey W. Hedenquist, of Ottawa, Canada, hearby certify that:

- I am President of Hedenquist Consulting, Inc., incorporated within the province of Ontario. I am an independent consulting geologist with an office at 160 George Street, Suite 2501, Ottawa, Ontario, K1N9M2, Canada; telephone 1-613-230-9191.
- I am a graduate of Macalester College, St. Paul, Minnesota, USA (B.A, Geology, 1975), The Johns Hopkins University, Baltimore, Maryland, USA (M.A., Geology, 1978), and the University of Auckland, Auckland, New Zealand (Ph.D, Geology, 1983); in addition, I have received degrees of Doctor *honoris causa* from the universities of Turku (2004) and Geneva (2014).
- International recognitions include the Kato Takeo Gold Award (2011), Society of Resource Geology of Japan; the Duncan Derry Medal (2005), Geological Association of Canada; the William Smith Medal (2004), The Geological Society (London); and the Society of Economic Geologists' Silver Medal (2000) and Ralph W. Marsden Award (2013).
- I have practiced my profession as a geologist continuously since 1975, working as a researcher for the U.S. Geological Survey, the New Zealand Department of Scientific and Industrial Research Chemistry Division, and the Geological Survey of Japan until the end of 1998. I have published widely in international refereed journals on subjects related to epithermal and porphyry ore-deposit formation and active hydrothermal systems. I consulted to the mineral industry and various governments as a New Zealand government scientist from 1985 to 1989, and I have been an independent consultant since January, 1999.
- I am a Fellow of the Society of Economic Geologists and have served in executive officer positions; I am also a member of the Society of Resource Geology of Japan and the Geochemical Society. I was Editor of the 100<sup>th</sup> Anniversary Publications of *Economic Geology* and am Associate Editor of the journal, as well as an editorial board member of *Resource Geology*; I have previously served as editorial board member of *Geology*, *Geothermics, Journal of Exploration Geochemistry, Geochemical Journal* and *Mineralium Deposita*.
- This report is based on information provided to me by Puddle Pond Resources, Inc., previous reports and discussions with personal named herein, and personal observations in the field.
- I have no direct or indirect interest in Puddle Pond Resources, Inc., in the properties described in this report, or in any other properties in the region.
- I hearby grant permission for the use of this report in its *full and unedited form* in a Statement of Material Facts or for similar purpose. Written permission must be obtained from me before publication or distribution of any summary.

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