Copperwood QA/QC

Theodore J. Bornhorst, Ph.D., P. Geo.

(a qualified person who is independent of Orvana Minerals Corp for the purposes of NI 43-101)

Orvana Minerals Corp, and its subsidiaries ("Orvana"), implemented a quality assurance and quality control (QA/QC) program to ensure that the collection and analysis of all Copperwood drill samples is of the highest quality and meets or exceeds C.I.M. Best Practices Guidelines and National Instrument 43-101 ("NI 43-101") standards of disclosure.

Core Security and Chain of Custody

Security measures were taken to insure the integrity and validity of the mineralized and proximal rocks obtained from the Copperwood drilling program.

1. Drill core was collected from the drill rig by a trusted person directly contracted by Orvana. The Orvana person will be under supervision of an Orvana QP.

2. The core was placed by the Orvana contracted person in core boxes that were labeled with permanent marker. Markers were placed in the core boxes clearly indicating the drillers depth at the end of each drill run.

3. When possible, a digital photograph was taken of the mineralized and proximal core in the field.

4. A **Chain of Custody** form was completed for each hole and remained with those boxes of mineralized and proximal core until the assay and density results were finalized. The Chain of Custody form indicated control and handling of the core.

5. The Chain of Custody form included field-depth estimates of critical contacts: top of Copper Harbor, top of Domino, top of Red Massive, and top of Gray Laminated lithologic units, the latter 3 being the **"copper-bearing sequence".**

6. Each individual box of mineralized and proximal core was "sealed" with shrink wrap in the short direction (not completely encased in shrink wrap). A permanent sticker label with signature completed the seal. This procedure protected the core both from unauthorized access and spillage if tipped.

7. The core was transported to the core logging/storage facility in Ironwood, Michigan by an Orvana contracted person using a truck or SUV. At the locked storage facility, the sealed core boxes remained signature sealed and were placed inside of a secure and locked cage if not signature sealed.

8. ONLY Orvana QPs broke the seal on the core and noted this on the Chain of Custody form. Prior to breaking the seal, the existing seal was inspected and verified as intact.

9. The sealed core boxes were transported for core processing by an Orvana contracted person using a truck or SUV. Prior to core processing, the seals were inspected by Orvana QP (Chain of Custody noted breakage), the core was generally inspected for tampering by Orvana QP, and the field depths were

compared to the core by Orvana QP. During the time the core was in control of Orvana QPs for core processing, the chain of custody form was not be updated.

10. During core processing, the sealed boxes with mineralized and proximal core was stored in a secure area to restrict access. During each step of core processing, the core was inspected by the Orvana QP to insure integrity.

11. Mineralized and proximal core will be photographed as part of core processing. Resolution of digital images will be high enough to be able to recognize basic geologic features.

12. After core processing was completed, the core was "sealed." Once the assay and density results were finalized and when core security was deemed by Orvana to be no longer necessary, the boxes were no longer sealed.

Core Processing

Only the mineralized and proximal core were subjected to core processing. These core represent the critical intervals for the Copperwood project. During all steps of core processing the core was secure.

Orvana completed drill holes are identified as CW (Copperwood)-XX (year completed)-XX (sequential hole number). For instance, hole 32 drilled during 2009 would be labeled CW-09-32, and on occasion abbreviated as 932. This number is the primary identifier for all holes. In 2008, hole number were 1 to 20 and in 2009 the numbers were 21 to 103.

1. **Depth Measurements.** The continuity of the core within and between rows of core in the boxes was checked by Orvana QP for every row in every hole to validate that no core was missing. **Core recovery was 100%.** ALL depths within the mineralized and proximal rocks are reverse hung on the total depth of the hole because this results in the very highest quality depth information at Copperwood.

2. **Lithologic Logging.** The Orvana QP determined the depths for every reported interval in every hole. The Orvana QP recorded the depths on a pre-printed paper form and signed each form upon completion. After assignment of depth intervals for the lithologic units by the QP, an assistant geologist remeasured all depths to insure accuracy and precision of the reported depths.

To insure the highest degree of consistency, the same Orvana QP lithologically logged ALL of the core and made all of the assignments of lithologic units. Only the mineralized and proximal core were subjected to intense core processing. Over this limited stratigraphic interval, the core was assigned to one of the following lithostratigraphic units: Copper Harbor sandstone, Copper Harbor siltstone, Domino, Red Massive, Gray Laminated, Red Laminated, Gray Siltstone, Red Siltstone, and Upper Sandstone. These lithologic units were defined in 2008 after careful review of the legacy drill core logs and the logging of the 5 drill holes completed in 2008. These lithologic units have recognizable features that readily facilitate their identification in the core. There are minor lateral lithologic variations within each unit, but these lateral variations do not significantly effect consistency of assignment of lithologic units. The contacts between these units vary from sharp to gradational. When the contact is gradational, the depth assignment can be somewhat arbitrary, but was generally within a 6-inch interval. The same Orvana QP made all assignments with a goal of maximum consistency. After assignment by the Orvana QP, an assistant geologist reviewed the contacts, especially those that are gradational. In some cases, the Orvana QP and assistant discussed final placement of a particular contact. This extra attention to detail insures high-quality data. After the depths are recorded on the logging form by the Orvana QP, an assistant remeasured them to eliminate possibility of measurement error.

3. **Geotechnical Logging.** The percentages of core recovery and rock quality for each drill run, which was as much as 10 feet or 3.05 metres, was determined in the field by an Orvana contracted geologist immediately after the drill core was placed into the core tray. All drilling and unnatural rock core breaks were identified using an industrial crayon. Yellow crayon was used to indicate *drilling induced fractures* by assigning an "X" to the break as well as colouring the fracture surfaces. A blue crayon was used to indicate *natural fractures*. The natural fractures were assigned by drawing blue lines parallel to the fractures. These data were used to determine a field RQD. The process was repeated in the laboratory to mark fractures that occurred during handling prior to core processing with a red crayon. These data were used to calculate a laboratory RQD. In addition, fracture frequency, average fracture spacing, nature of fracture surfaces, fracture filling, and degree of weathering for each core run (DW) were also recorded. This protocol was supervised by an Orvana QP.

4. **Rock Mechanics Testing.** During coring operations, point-load testing, using an industry standard point-load device with a digital pressure gage following the procedures defined by ASTM D 5731-07, was made at approximately 2-foot intervals to break the core to be placed into the core boxes. The point-load testing in the field was conducted by an Orvana contracted geologist under supervision of an Orvana QP. While the RMR classification system allows the use of point-load test data directly, uniaxial testing were also conducted on the rock core to develop a correlation between the point-load test results and the uniaxial compression test results for the stratigraphic units at Copperwood. This testing was under the supervision of an Orvana QP.

5. **Core Photography**. The ore and proximal core from drill holes were photographed prior to cutting the core. The photographs were taken in a controlled environment using color-balanced light and at a resolution to be able to recognize small-scale features in the core. The "From" and "To" for each box in the photographs was the edge of the box value assigned by the Orvana QP during core processing.

A second photograph is taken for this core with the core cut at the lithologic unit breaks and a coloured wood block inserted at the contact. Thus, these marked photographs highlighted the lithologic contacts. After photographing, the wood block was replaced with a coloured card-stock marker where the depth was recorded with a permanent marker.

6. **Assignment of Assay and Density Intervals**. The same Orvana QP assigned ALL assay and density intervals. The assigned intervals were recorded on a pre-printed paper form and signed by the QP. After completion, an assistant geologist remeasured all assay interval breaks for all holes to insure the accuracy of the depth and the numbers recorded on the paper forms.

The assay sampling intervals for drill holes were constrained by several project goals. Orvana desired to use ½ of the core for geochemical assay for Cu and Ag as well as analyses for other elements, 1/4 of the core for metallurgical testing, and 1/4 of the core for archive. The rejects from the geochemical analyses were sealed and stored in a dry and cool environment since they will be used for metallurgical testing.

Dry bulk-density determinations by wax immersion can result in residual wax remaining on the sample, which would interfere with preparing pulps for geochemical assay as well as with crushing for metallurgical testing. Thus, the archived ¼ core was used for bulk-density determinations. Each bulk-density-interval was paired with copper assay. These paired data allow for the establishment of a density-grade model that will be a part of the resource calculations. There were practical constraints on the length of interval used for density determinations. The interval cannot cross lithologic unit boundaries; hence typically for Red Massive (a thin unit) the entire interval was used for determination of density. The major mineralized lithologic units, Domino and Gray Laminated, were composed of laminated siltstone to shale. Even before cutting, the core tends to delaminate into segments due to drying. Cutting of the core in half results in further delaminated segments since it uses water for lubrication. The further cutting of the core into ¼ generates even more segments. The end result is that after cutting to ¼ of original size, a one-foot interval of core can readily consist of 20 to 30 individual segments of varying size. Each of these segments must be carefully waxed, which makes determination of density time consuming and expensive. Given the practical constraints, the intervals assigned for density determination average about 0.9 feet. The project goal was to determine density-assay pairs for 50 representative intervals from each of the 3 main mineralized lithologic units within the copper-bearing sequence. Initially, assigned density intervals were adjacent to lithologic contacts or towards the center of the unit to yield the remaining intervals as long as possible up to 3 feet long. However, upon return of initial assay results, it was obvious that the upper 1 foot of Domino was consistently enriched in copper as compared to the rest of Domino to the extent that these short, high-copper intervals could be clipped as anomalous during resource calculations. Thus, the upper 1 foot of Domino was avoided during remaining assignment of intervals for density. Density could not be determined on core that was too broken by secondary joints and fractures or post drilling delamination. Cumulatively, the intervals selected for density cover the entire range of stratigraphic positions from bottom to top of each mineralized unit and were representative of the entire range of lithologic variations of mineralized rocks.

The length of intervals assigned for sampling and assay depended on whether density was to be determined within the interval, the thickness of the lithologic unit, and natural breaks in the core. The two lithologic units below and above the mineralized horizons (Copper Harbor and Red Laminated) were sampled on approximately three sequential 1-foot intervals starting at the adjacent mineralized lithologic unit contact. For the three lithologic units regarded as the copper-bearing sequence (Domino, Red Massive, and Gray Laminated), the maximum interval length was 3 feet. If the lithologic unit was less than 3 feet thick and without a density interval, it was composited into one sample. If the interval was greater than 3 feet and without a density interval, it will be subdivided into subequal parts for sampling as long as no part is greater than 3 feet. The subparts of lithologic units were not exactly equal due to adjustments made to the interval because of natural breaks in the core (eliminated the need for lateral cutting of the core), breakage by secondary joints and fractures, and, in a few cases, vertical lithologic variation within the unit. In ALL cases the diameter of the core was inspected to insure that the diameter of the core was constant within an assay interval. In a few cases, small intervals were assigned to insure constant diameter of core within the intervals.

7. **Cutting and Sampling the Core.** Prior to cutting the core into half and quarters, the core is laterally cut and card stock markers placed at the ends of all assay intervals with the depth written using permanent marker. Colored card stock markers are used for lithologic unit contacts and white for other assay depths. The markers were either placed or checked by the Orvana QP and double checked by an assistant geologist or the Orvana QP.

Orvana completed drill holes were identified as CW (Copperwood)-XX (year completed)-XX (sequential hole number). Secondary identification of sampling intervals used the sequential hole number preceded by an 8 for 2008 holes and a 9 for 2009 holes. This was followed by a number representing the deepest depth of the sampling interval recorded to one place to the right of the decimal excluding the decimal and without rounding. For example, if CW-09-32 was sampled between 680.38 to 681.38, the sample number would be 9306813. The last digit of the depth number is not rounded, but is the actual number. The inclusion of the depth in the sample number minimized the chance for error and yet leaves sufficient available numbers between sampled intervals for inclusion of QA/QC samples using the same number pattern.

The Orvana QP was present while all core was cut and placed all cut core into the pre-numbered sample bags. Before cutting an interval, the number on the sample bag was checked by the Orvana QP against the number on the interval markers. The actual cutting of the core was carried out under direct supervision of the Orvana QP and for all but a few holes the core was consistently cut by the same person. Cutting was done in a manner to insure that the assay half of the core was complete so that if chips were missing from the side of the core, this side was not used for the assay sample. Depending on the condition of the core, the ¼ metallurgical and ¼ archive splits could be less than complete. The Orvana QP periodically weighed the cut halves and quarters of core to insure consistent halving and quartering of the core. Fine-scale adjustments to the fence were only done between intervals so cutting within intervals is consistent. Immediately upon cutting each length of core, the cut core was placed into its bags by the QP to ensure the highest quality of sample since the core was delaminated/fragmented during cutting. When a sample interval was complete, number on the bag was rechecked.

One or more short intervals of the lower Domino, intervals with abundant secondary joints/fracture, or intervals used in rock testing were too fragmented for cutting. For these intervals, the core was crushed in a jaw crusher and split using a riffle splitter. Special care was taken to ensure that any fines in the core box were included in the pre-split sample. The Orvana QP directly supervised, in person, all of this activity and did all of the final splitting and bagging. For the first 20 holes, difficult-to-cut intervals were handled in a different fashion. The core was tightly wrapped in plastic wrap for cutting. Once cut, the assay half was "butterflied" and put into the sample bag. The sample was rewrapped for quartering. While this method produced high-quality, representative splits of the core, it was abandoned since it could not be used to cut more fractured and geotechnically tested intervals.

After cutting, the bags of samples were dried at 40^{o}C for at least 4 hours to remove water that resulted from cutting in a locked drying oven. The samples were dried again at the analytical laboratory. The top of each sample bag was "sealed" with a cable tie. The individually-sealed bagged samples were placed in another bag for each hole, and then stored in a locked and secured area prior to shipment to Actlabs. Blanks and Certified Referenced Materials were inserted within the same number sequence, but as unknown samples, by the Orvana QP.

Bulk Density Determinations

The intervals for determination of bulk density were selected by Orvana QP within several constraints including lithologic contacts, condition of the core before cutting, probable fragmentation and delamination of the core during quartering in order to minimize interruption of selected assay intervals (e.g., creating two back-to-back short intervals).

1**. Bulk Density General Procedure.** Bulk density (dry) was determined for the three main lithologic units of the copper-bearing sequence using the wax-immersion method. The wax-immersion method is appropriate for the Copperwood Project since the rocks have limited to no surface pore space that can be readily penetrated by the wax.

Cumulatively, the intervals from the copper-bearing sequence were selected to represent the entire range of stratigraphic positions from bottom to top of each mineralized unit as well as geographically throughout the deposit. The samples used for density are representative of the entire range of lithologic variations of mineralized rocks and lateral variations. In addition to the copper-bearing sequence, density measurements were made on multiple samples from the overlying hanging wall unit (Red Laminated).

2. **Bulk Density Analytical Procedures.** All bulk density determinations are on a dry basis (drying 24 hours at 110 ^{o}C). Density determined by the wax-immersion method followed the procedure defined in ASTM C914 – 09. For the wax-immersion method, quartered core from designated intervals was used for determining bulk density. Since the quartered core was in several individual pieces, the density was determined by weighing all individual pieces cumulatively for a dry weight. Each individual piece was carefully wax coated with care to remove all trapped air from the wax. The cumulative weight of the waxed pieces was measured. The cumulative suspended weight was determined by placing all individually waxed pieces into a submerged wire basket. All weights were measured using certified scales with a 0.01 gram accuracy. In most cases this represents 5 significant digits, which are better than the 4 significant digits recommended in ASTM C914 – 09. The density of the wax was determined by a calibrated helium pycnometer (Micromeritics AccuPyc 1330) to 0.001 gram per cubic centimeter (gm/cc). Specific gravity determined by the wax-immersion method had to be multiplied by the density of water to yield density. The temperature in the laboratory was 21^{o}C plus or minus 1^{o}C which results in a water density of 0.998 gm/cc.

The bulk density was calculated to 0.001 gm/cc. However, the final accepted bulk density for Copperwood core intervals is reported to 0.01 gm/cc as this more accurately reflects the analytical errors.

3. **Bulk Density QA/QC**. QA/QC for bulk-density determinations was monitored by several different approaches. The bulk density of three sets of internal quality-control whole-core samples was determined multiple times to estimate precision. The bulk density of these segments was determined by the caliper method and compared to the wax immersion method to estimate accuracy. The bulk density for 16 intervals of Copperwood core and 2 quality-control samples was determined by an independent consultant using the wax immersion method to estimate accurracy. The bulk density for 11 intervals of Copperwood core was duplicated by the wax-immersion method by carefully removing the wax after the first determination to provide another estimate of precision.

Copper and Silver Determinations

Activation Laboratories Ltd. (ACTLABS) was the primary geochemical analytical laboratory. ACTLABS is an ISO/IEC 17025 and CAN-P-1579 registered laboratory (ISO/IEC 17025 includes ISO 9001 and ISO 9002 specifications). ACTLABS has a rigorous chain of custody protocol in place to ensure security of samples once received at the lab. The primary analytical protocol for Copperwood samples was: Code RX2 with terminator: Crush and pulverize sample, Code 8: Assay Copper (> 0.2 % Cu) and Assay Silver (>25 ppm Ag), Code 1E2: Silver (< 25 ppm Ag) and Copper (<0.2 % Cu) along with a multiple-element scan.

ACTLABS processed samples to be crushed in the order provided in the Shipment sample list. In addition, the lab was instructed to analyze the samples in the order provided in the Shipment sample list. This allows for higher-quality placement of coarse blanks to be crushed and Certified Reference Materials to be analyzed. The lab was instructed to retain 100% of the coarse rejects and the pulps, and return them once instructed by Orvana QP.

ALS Chemex - Sudbury (ISO17025 accredited) was the secondary laboratory for duplicate check analysis. The analytical method used was the same as the primary laboratory.

Copper and Silver Determination Quality Assurance and Quality Control (QA/QC)

A rigorous QA/QC program established by an Orvana QP was carried out for analyses at the primary and secondary laboratories. QA/QC samples were inserted in the within the same number sequence and same style of numbers as unknown samples by an Orvana QP. The laboratory batch size was considered to ensure sufficient QA/QC samples.

1. **Certified Reference Materials (CRM**). The purpose of inserting CRMs is to assure the accuracy of the analytical results and to monitor precision. Orvana used 8 CRMs for the Copperwood Project ranging from roughly 0.5 to 6.5 % copper. A batch of Copperwood samples contained more than 10 % CRMs. Upon receipt of the analytical results, the Orvana QP first checked the results for the CRMs within the overall batch of samples. If any CRM was outside of 3 standard deviations of the recommend CRM value, the lab was immediately notified and all data in the batch were put on hold until the issue was resolved to the satisfaction of the Orvana QP. If more than 10 % of the CRM determinations were between 2 and 3 standard deviations of the recommend CRM value, all data in the batch were put on hold until the issue was resolved to the satisfaction of the Orvana QP. If CRM results had either consistently low or high bias for over 4 or more CRMs in a row, all data in the batch were put on hold until the issue was resolved to the satisfaction of the Orvana QP. The resolution of quality issues may not result in improvement of CRM performance as long as the laboratory produces sufficient evidence of accurate results. The stated laboratory accuracy was 1 to 3 % for assays. The results were deemed acceptable and entered into the Copperwood database as final so long as the average deviation of the laboratory and certified values for all of the CRMs within the batch was less than 3 %.

The CRM data provided by the laboratory also constituted part of the assessment of the accuracy of the analytical results.

2. **Coarse Blanks**. The primary purpose of the coarse blanks was to assess carry-forward contamination during crushing and pulverization of the core. The principal coarse blanks for the Copperwood project were quartzite from Upper Michigan and fragmented annealed glass. A batch of Copperwood samples contained more than 7% coarse blanks distributed such that there was at least one coarse blank for each set of samples from a single drill hole. Within a set of samples from a single drill hole, the placement of the coarse blank was more frequently placed between samples with expected higher grades of copper since there is a higher probability of carry-forward contamination. The first sample of each batch was a coarse blank to ensure no carry-forward contamination from samples of a different area.

3. **Pulp Blank.** The purpose of the pulp blank is to assess contamination during the dissolution process and the zero intercept of the laboratory calibration. A batch of Copperwood samples contained more than 3.5% pulp blanks distributed throughout the batch. A low copper and low silver CRM was inserted in each batch. The blank data provided by the laboratory also constituted part of the assessment of the analytical results.

4. **Pulp Duplicates.** The purpose of duplicates submitted to the primary laboratory is to determine the precision of primary laboratory. Pulp duplicates were handled by two independent approaches. The laboratory was requested to pull selected pulps during original sample submission and requested to do an additional complete dissolution and reassay. At least 3.5% of the pulps were selected for immediate reanalysis. In addition, at least 3% selected pulps returned from the primary laboratory were grouped into a subsequent batch of samples for analysis by the primary laboratory to provide between-batch precision. Pulp duplicate samples were biased towards those samples above 0.5 % copper as this is the critical range of copper abundance. The specific samples were designated by the Orvana QP. Relative error for duplicate samples of more than 10% was considered a threshold for concern and action.

The pulp duplicate data provided by the laboratory all constituted part of the assessment of the precision of the analytical results.

5. **Coarse duplicates.** The purpose of coarse duplicates was to monitor precision involved with the combined effect of producing a new pulp (representativeness of the splitting of the coarse crush) and simply analysis precision. Coarse duplicates were handled by two independent approaches. The laboratory was requested to pull more than 2.5% of the coarse rejects prior to return of samples for immediate pulverization and reassay within the same batch of samples. In addition, at least 2% selected coarse rejects returned from the primary laboratory were grouped into a subsequent batch of samples for analysis by the primary laboratory to provide between-batch precision. Coarse duplicate samples were biased towards those samples above 0.5% copper as this is the critical range of copper abundance. The specific samples were designated by the Orvana QP. Relative error for duplicate samples of more than 10 % was considered a threshold for concern and action.

The coarse duplicate data provided by the laboratory also constituted part of the assessment of the precision of the analytical results.

6. **Check Duplicate Samples.** The purpose of check samples, or those samples sent to a different (secondary) laboratory, was to further assess the accuracy of the primary analytical results. Pulp duplicates were submitted to the secondary laboratory by selecting pulps from samples returned from the primary laboratory. The pulps returned from the primary laboratory were submitted to the secondary laboratory using the same number sequence with added letters to distinguish these samples from the original analyses. At least 6% of the Copperwood samples were selected for check duplicate analysis (>5 %). The check duplicate assay batch included CRMs and pulp blanks in the proportion described above. Bias of more than about 5 % was considered a threshold for concern and action.

In sum, the Orvana geochemical analytical program included a minimum of: 10% CRMs, 7% coarse blanks, 3.5% pulps blanks, 6.5% pulp duplicates, 4.5% coarse duplicates, and 6% check duplicate samples, i.e., 35% of the sample population. Statistical analysis of data was performed to quantify accuracy and precision of the analytical results.