Sawyer-Keystone Trend of Au-Ag-As deposits in Randolph County, North Carolina: Geologic and metallogenic analysis

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Foreword

Introduction and statement of purpose

This report is one of a series of four North Carolina Geological Survey open-file reports and North Carolina Geological Survey, Special Publication 11, prepared in cooperation with the North Carolina Geological Survey, that provide a geologic and metallogenic review and analysis of several groups and associations of historic gold mines in the Carolina Terrane in central North Carolina. Although representing diverse styles of mineralization, the gold deposits reviewed in these reports all appear to represent a broad spectrum of orogenic gold deposits within the classification of **Grooves *et al*. (1998)**. This includes classic low-sulfidation mesozonal orogenic narrow-vein lode gold deposits, represent by mines of the Gold Hill District (Gold Hill-type) and similar deposits along the Gold Hill Fault Zone (**Moye, 2016**); a newly recognized style of large-tonnage, low-grade mesozonal orogenic deposits with disseminated and stockwork vein mineralization (Sawyer Type); and a possibly unique occurrence of epizonal orogenic mineralization with bonanza-grade Au-Ag-Te mineralization. Deposit analysis indicates that, although geographically widespread and hosted by rocks with a wide range of ages, these various styles of orogenic gold deposits all formed during the Cherokee Orogeny in the late Ordovician to early Silurian (**Hibbard *et al.*, 2012**).

Sawyer-type high-tonnage mesozonal orogenic deposits

The newly defined Sawyer-type mesozonal orogenic gold deposits include mineralization at the historic New Sawyer, Sawyer, Jones-Keystone, and Lofflin mines in northwest Randolph County; the Russell and Coggins mines in the Ophir District in Montgomery County; and possibly the Burns-Allen-Red Hill deposit near Robbins in Moore County, North Carolina.

These deposits are characterized by often multiple parallel or *en echelon* lenses of silicic ore-grade mineralization, meters to tens of meters wide and tens to hundreds of meters long, enclosed by zones of pyritic phyllic alteration tens to hundreds of meters wide and often hundreds to thousands of meters long. Alteration and mineralization intensity are heterogeneous and gradational with indefinite boundaries, and ore grade is typically determined by assay. The large volume of rock that has experienced pervasive sulfidation in these deposits could arguably be compared to high-sulfidation alteration.

Gold occurs with disseminated pyrite and narrow, millimeter-scale, cleavage-parallel quartz ± pyrite vein swarms and stockworks. Sulfide minerals average about 2-5 vol%, locally up to 10 vol%, dominated by pyrite ± accessory arsenopyrite ± minor pyrrhotite with trace base metal sulfides. The characteristic trace element association for Sawyer-type gold mineralization is Au ± Ag ± As ± Mo ± Pb ± Sb and trace to geochemically anomalous Cu and Zn.

These deposits appear to have formed within discontinuous deformation zones characterized by reverse faults that are often axial to appressed, northeast-trending meso-scale anticlines with axial planes that dip steeply to the northwest. Although commonly classified as structurally modified syngenetic exhalative gold-rich massive sulfide deposits, alteration and mineralization are confined to the host structures and synkinematic with ductile-brittle deformation under regional lower greenschist facies metamorphic conditions.

Within the oxidized zone, pyrite dissolution results in acid leaching with deep (~30 meters) weathering and the formation of free gold, often with increased fineness and coarser grain size compared to gold in primary sulfide ore, and surface and supergene enrichment to form large-tonnage, low-grade, easily mined and processed ore deposits. These deposits were historically mined by open-pit methods to the water table, with more localized underground mining of narrow, high-grade zones of secondary oxide, mixed, and primary sulfide mineralization.

Considerations of economic potential

Sawyer-type deposits are among the more attractive targets for modern precious metals exploration programs in the Carolina Terrane in central North Carolina. This is based on the indicated potential for large-tonnage, bulk-minable, low-grade deposits with relatively high gold recovery at low unit cost over a significant mine life. Evaluation of these deposits has historically involved extensive surface sampling and a broad variety of geophysical surveys, but minimal subsurface evaluation through drill-hole testing, mostly to relatively shallow depths. Due to the heterogeneity of gold distribution in this style of mineralization, even a few dozen drill-holes are unlikely to provide an adequate estimate of the grade and tonnage of the gold resource.

Additionally, the structural and lithologic controls of mineralization are often poorly understood, and the misapplication of incorrect ore deposit models may result in wasted drill-holes and discouraging results. An early investment in detailed geologic mapping and structural analysis, coupled with comprehensive petrographic and mineralogical analyses to fully constrain ore controls, is strongly recommended for the predictive constraints of this approach.

Historic open cut mining of Sawyer-type deposits typically focused on recovery of oxidized ore with free-milling gold at grades of generally 0.10 to 0.30 oz/t Au, leaving lower-grade (0.01-0.09 oz/t Au) oxide ore on the periphery and as “horses” within the open cuts. Additionally, zones of highly siliceous unoxidized sulfide ore that was difficult to mine and mill was also left as “horses”. Although much of the easily mined and milled oxide ore above the water table (~20-30 meters depth) in many deposits was historically depleted, much of the lower-grade oxide ore remains, along with mixed oxide/sulfide and primary sulfide mineralization present at greater depth.

Intercepts of primary sulfide ore in those deposits that have been drill-hole tested commonly contain tens of meters of low-grade mineralization (0.01-0.10 oz/t Au) with narrow (meters) intervals of higher-grade values (0.10-0.25 oz/t Au). However, few deposits have been adequately drilled to establish a reliable estimate of grade and tonnage, given the notoriously heterogeneous gold distribution in primary sulfide ores. This same problem was inherent in the evaluation of the Kennecott Ridgeway and Oceanagold Haile deposits in South Carolina, where hundreds of drill-holes were required to define the minable resources.

One of the only Sawyer-type deposits to be adequately drill-hole tested is the Russell

Mine in the Ophir District in northwest Montgomery County, North Carolina. The deposit has an estimated historical production of around 37,500 ounces Au, plus drilling-based estimates of proven, probable, and possible reserves of over 300,000 ounces of gold (**Maddry *et al.*, 1992**) with a total resource around 350,000 ounces in oxide, sulfide, and mixed ore. This resource represents only the upper 150 meters of two of the five known mineralized zones on the property.

The vertical extent of Sawyer-type mesozonal orogenic gold deposits has not been tested, although historic mining, topographic exposures, and modern drill-hole testing suggest a vertical extent of at least 500 meters. The character of the structural controls of ore fluids and their likely source in the middle crust suggests possible vertical extents of over a kilometer. The presence of narrow zones of bonanza-grade Au mineralization in some deposits suggest a distinct potential for underground mining targets, possibly within ore fluid feeder zones similar to those discovered at the Haile Mine and associated with Carlin-type disseminated gold deposits in Nevada.

Star-Carter bonanza-grade epizonal orogenic deposits

The Star-Reynolds and Carter gold mines in Montgomery County, North Carolina are located about 2,000 meters apart along narrow faults that strike 030° and dip ~50° northwest, possibly as part of an *en echelon* fault zone with a strike length of at least 2,000 meters. Both mines produced around 20,000 ounces of gold from surface placer deposits and narrow zones of high-grade lode mineralization along strike-lengths of less than 100 meters to a depth of 20-30 meters. Bonanza grade shoots rich in Au-Ag tellurides at the Star Mine contained as much as 10-20 oz/t Au (**Phifer, 2004)**, with similar grades from selected vein samples at the Carter Mine.

There appear to be two stages of mineralization present. The dominant form is narrow (<2 meters), cleavage-parallel shear zone hosted sheeted or stockwork quartz veins and silicic alteration with disseminated sulfides and carbonates. These zones carry locally high-grade Au-Ag mineralization and are enclosed by narrow haloes of phyllic alteration with disseminated auriferous pyrite. Sulfides are dominantly pyrite with minor accessory chalcopyrite ± molybdenite ± gold telluride ± minor bornite and chalcocite with geochemically anomalous Sb, As, Pb, and Zn. This style of mineralization is consistent with mesozonal orogenic gold deposits formed at depths of 6-12 kilometers and temperatures of 300°-475°C (**Grooves *et al.*, 1998**).

This mesozonal orogenic vein mineralization is overprinted by brittle faulting at the Star and Carter mines, with locally bonanza-grade Au-Ag-Te mineralization (**Powers, 1989**, **Phifer, 2004**). At the Star Mine, high-grade gold + sylvanite [$(Au,Ag)Te_2$] + calaverite ($AuTe_2$) occur in chimneys within the plane of the brittle fault zone, characterized by silicified clasts in a clay-rich gouge matrix. In the absence of associated felsic igneous intrusive rocks, this mineralization is consistent with epizonal orogenic deposits formed in the upper 6 kilometers of the crust at temperatures of around 150°-300°C (**Grooves *et al.*, 1998**; **Cook *et al.*, 2009**).

Trace element associations suggest that both styles of mineralization are associated with a single hydrothermal event. The transition from ductile-brittle to brittle deformation is possibly due to orogenic crustal thickening and uplift, followed by rapid denudation through gravitational collapse or rapid weathering within the duration of the mineralizing event.

Evaluation of the Carter Mine by Noranda in 1987-1988 suggests that the presence of a large-tonnage, bulk minable gold mineralization target is unlikely (**Powers, 1989**). However, a total of 40,000 ounces Au was produced from only 200 meters of strike along a fault zone at least 2,000 meters long, and mostly from surface accumulations and the upper 20-30 meters of the lodes. There is a distinct possibility that a series of bonanza-grade Au-Ag-Te ore bodies may be present along the 2,000-meter strike of the Star-Carter fault zone in Montgomery County, North Carolina, both near the surface and at depth, that could be mined profitably with a small footprint.

Acknowledgements

This series of reports is the result of a productive relationship with the North Carolina Geological Survey, dedicated to providing mining industry-based information and insights into the character and economic potential of base and precious metal mineralization in the Carolina Terrane in central North Carolina.

The success of this partnership is directly attributed to the indefatigable energy and commitment of Dr. Jeffrey C. Reid PhD, PG, CPG, Senior Geologist, Energy and Minerals of the North Carolina Geological Survey, Division of Energy, Mineral and Land Resources, North Carolina Department of Environmental Quality. His encouragement and organizational and editing skills have been instrumental in bringing this project forward.

Additionally, these studies have benefitted enormously from the published resources of the North Carolina Geological Survey, the United States Geological Survey, and the remarkable academic achievements in constraining the stratigraphy, structure, and geochronology of the Carolina Terrane in North Carolina over the past 20 years. These contributions are reflected in the list of References Cited in these papers.

Many accomplished geologists have contributed to understanding the character and evolution of the geology of the Carolina Terrane and the hydrothermal ore deposits that it hosts. It is important to remember that well-trained geologist make accurate and useful observations. It does not dismiss or diminish their contributions to modify or disagree with their interpretations.

Finally, I strongly encourage the mineral deposit exploration geologists who were active in the Southeastern USA piedmont in the 1970s-1990s to contribute their reports, maps, and data to public institutions, such as state geological surveys and universities, to preserve and pass on hard won and valuable natural resource knowledge for the benefit of society. Don’t allow information to languish and disappear. You had a fair go; now give someone else a chance.

References

Cook, N. J.; Ciobanu, C.L.; Spry, P.G., and Voudouris, P., 2009, Understanding gold-(silver)-telluride-(selenide) mineral deposits: Episodes v. 32, no. 4, p. 249-263.

Groves, D.I.; Goldfarb, R.J.; Gebre-Mariam, M.; Hagemann, S.G., and Robert, F., 1998, Orogenic gold deposits; A proposed classification in the context of their crustal distribution and relationship to other gold deposit types: Ore Deposit Reviews, v. 13, p. 7-27.

Hibbard, J.; Miller, B., Hames, W.; Standard, I.; Allen, J.; Lavallee, S., and Boland, I., 2012, Kinematics, U-Pb geochronology, and 40Ar/39Ar thermochronology of the Gold Hill shear zone, North Carolina; The Cherokee orogeny in Carolinia, Southern Appalachians: GSA Bulletin, v. 124, no. 5/6, p. 643-656.

Maddry, J.; Hart, W., and Dail, C., 1992, Exploration summary, Russell Project, Montgomery and Randolph counties, North Carolina: Unpublished report for Piedmont Mining Company Incorporated, Charlotte, NC, 23p.

Moye, R.J., 2017, Metallogenesis of the central Gold Hill District of the Carolina Terrane, Rowan and Cabarrus Counties, North Carolina: in, Moye, R.J.; Reid, J.C., and Lee, D.F.: Volcanogenic polymetallic massive sulfide deposits (VMS) of the Carolina Terrane in central North Carolina; New perspectives and historical reports and data from the files of Phelps Dodge Exploration East (1975-1982). North Carolina Geological Survey, Special Publication 11, 45p.

Phifer, S.E., 2004, The Carter and Reynolds Gold Mines; Is There a Yet Unknown, but Mineable Gold Deposit Here: ICMJ's Prospecting and Mining Journal. Viewed on-line March 8, 2018 at url https://www.icmj.com/magazine/article/the-carter-and-reynolds-gold-mines-is-there-a-yet-unknown-but-mineable-gold-deposit-here-1167/.

Powers, J.A., 1989, Carter Project, North Carolina - Final Report: Unpublished report for Noranda Exploration, Inc., Cary, North Carolina, 24p.

Related reports (Available at https://deq.nc.gov/about/divisions/energy-mineral-land-resources/north-carolina-geological-survey/ncgs-maps/open-file-reports-maps)

Moye, R.J., 2018-15, Ophir District, Randolph and Montgomery Counties, North Carolina – geologic and metallogenic analysis: North Carolina Geological Survey, Open-File Report 2018-15, 71p.

Moye, R.J., 2018-16, Glendon and Robbins AES alignments in the Carolina Terrane of central North Carolina: Review of geology and metallogeny: North Carolina Geological Survey, Open-File Report 2018-16, 71p.

Moye, R.J., 2018-17, Star-Reynold and Carter gold mines, Montgomery County, North Carolina: Review of geology and metallogeny: North Carolina Geological Survey, Open-File Report 2018-17, 32p.

Moye, R.J., 2018-18, Sawyer-Keystone Trend of Au-Ag-As deposits in Randolph County, North Carolina: Geologic and metallogenic analysis: North Carolina Geological Survey, Open-File Report 2018-18, 44p.

Moye, Robert J.; Reid; Jeffrey C., and Lee, David F., 2017, Volcanogenic polymetallic massive sulfide deposits (VMS) of the Carolina Terrane in central North Carolina: New Perspectives and historical reports and data from the files of Phelps Dodge Exploration East (1975-1982): North Carolina Geological Survey, Special Publication 11, 456p. Available on-line at URL https://files.nc.gov/ncdeq/Energy%20Mineral%20and%20Land%20Resources/Geological%20Survey/SpecialPublications/NCGS_Special_Publication_11_Volcanogenic_sulfide.pdf.

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Sawyer-Keystone Trend of Au-Ag-As deposits in Randolph County, North Carolina: Geologic and metallogenic analysis

By Robert J. Moye

Abstract

An irregular alignment of at least a dozen historic gold mines and prospects extends for 21 kilometers on a trend of about 065° through northwest Randolph County, North Carolina, across the Albemarle Sequence of the Carolina Terrane. The largest and most productive of these deposits include the New Sawyer, Sawyer, Jones-Keystone, and Lofflin mines.

Although hosted by different formations of the Albemarle Sequence, all of these deposits share similarities in the character of hydrothermal alteration, style and tenor of gold mineralization, and apparent structural and lithologic controls. Mineralization is characterized by 3-5 vol% fine-grained pyrite ± pyrrhotite ± arsenopyrite ± trace base metal sulfides as disseminated grains, thin sulfide stringers, and as accessories in thin quartz ± carbonate veinlets that occur as irregular stockworks and cleavage-parallel swarms. Gold and silver are the only economic commodities recovered.

Ore grade mineralization occurs in multiple parallel to *en echelon* lenses of typically intense silicic alteration 1-10 meters thick and tens to hundreds of meters long, with historic mining grades of 0.25- 0.50 oz/t Au in oxidized ore. The ore lenses are enclosed by zones of strong phyllic alteration tens of meters thick with geochemically anomalous to low-grade (0.03-0.10 oz/t Au) gold mineralization. Multiple zones of hydrothermal alteration and gold mineralization with strike lengths from hundreds of meters to over a kilometer are typically present at the major historic mines.

The structural controls for these deposits are characterized by discontinuous NNE-trending reverse-sinistral displacement shear zones and related meso-scale appressed folds with strongly developed axial planar cleavage. The deformation within these zones contrasts strongly with the less-strongly deformed surrounding host rocks. Deformation, alteration, and mineralization appear to be synchronous with regional greenschist facies metamorphism and localized second-order folding during the later stages of the Cherokee Orogeny (**Hibbard *et al.*, 2012**), but formed at an oblique angle to earlier structures and fabrics.

This form of relatively low-grade but high-tonnage gold mineralization is a potentially economic bulk-minable, high recovery precious metals exploration target that has attracted periodic evaluation since the mid-1970s. Along with the Russell and Coggins deposits in the Ophir District of Montgomery County, North Carolina, Sawyer-type gold deposits appear to be a poorly defined style of deep epizonal to shallow mesozonal orogenic gold mineralization.

Introduction

This study attempts to draw together all available information on the geology, mineralization, and mining and exploration history of the gold deposits of the Sawyer-Keystone Trend in northwest Randolph County, North Carolina. The larger deposits of this group have been the focus of renewed interest by mining companies since the mid-1970s as possible economic targets for large tonnage, low grade, and bulk-minable gold mineralization.

The character and age of these deposits has been controversial, and most are currently classified in the USGS MRDS database as ore deposit *Model 25a: Hot-spring Au-Ag* (https://pubs.usgs.gov/bul/b1693/html/bull0g4n.htm), based on the work of **Berger (1985**). However, detailed analysis suggests that these deposits are a possible deep epithermal to shallow mesothermal, structurally controlled style of orogenic gold mineralization formed synchronously with regional compressive deformation and greenschist facies metamorphism of the Albemarle Sequence of the Carolina Terrane in central North Carolina during the later phases of the Cherokee Orogeny in the late Ordovician to early Silurian (**Hibbard *et al.*, 2012**).

The general character of these gold deposits, their regional and local geologic setting, and the probable timing of their genesis is presented in an opening **Geologic Summary** (below). This is followed by detailed descriptions of the geology, alteration and mineralization, and mining and exploration history of the known mines and prospects. The geologic and metallogenic character and of these deposits is reviewed and analyzed in detail and contrasted with other gold deposits of the Carolina Terrane in the **Discussion** section, with a proposed ore deposit model for their genesis. The final section explores the economic potential of this type of gold deposit as a viable exploration target.

In this report, historic gold values reported as dollar amounts have been converted to ounces per ton (oz/t) using historical USA gold prices for the year of publication. Except in discussions of geochemistry, mineral chemistry, and trace element concentrations, gold values reported as part per million (ppm) or parts per billion (ppb) are reported in grams per tonne (g/t) and ounces per ton (oz/t); where 1ppm Au = 1 g/t Au, 34.28 g/t Au = 1 oz/t Au.

Limitations of the study

This study is based largely on available published geologic studies and documentation of the gold deposits of the Sawyer-Keystone Trend and the direct personal experience of the author as an exploration geologist working throughout the region during the 1980s and 1990s. A much larger body of information on some of these deposits is held in the proprietary files of individuals and corporations, but is not available in the public sector. This is especially true of the New Sawyer, Sawyer, Jones-Keystone, and Lofflin mines; and attributed to their potential as economic gold resources.

The locations for some of the minor deposits discussed are indefinite, and limited historical and geologic information is available for these deposits as well. The Wilson Kindley Mine is included in this report because it is listed in available records, although it was an attempted fraud salted with gold-bearing ore from another mine.

This work is part of an ongoing metallogenic analysis of the Carolina Terrane, which seeks to correlate specific types of precious and base metal mineralization with specific lithotectonic environments and metallogenic events in the geologic history of the Carolina Terrane. The analysis is intended to better focus and constrain future exploration and analysis of metallic ore deposits in the Southeastern piedmont of the United States of America.

Geologic summary

An irregular alignment of at least a dozen gold occurrences in northwestern Randolph County trends about 065° for 21 kilometers across the Albemarle Sequence of the Carolina Terrane in central North Carolina (**Figure 1** and **Figure 2**). Most of these occurrences are described as indefinite zones of cleavage-parallel phyllic to silicic alteration with 3-5 vol % pyrite ± pyrrhotite ± arsenopyrite as disseminated grains, sulfide stringers, and in cleavage-parallel quartz veinlets and stringers. The alteration and mineralization appear to be developed along discontinuous, possibly *en echelon* shear zones. The orientation of this alignment is not generally consistent with observed major tectonic fabrics or trends in this portion of the Carolina Terrane.

From west to east, gold deposits are hosted by the Cid, Tillery, and Uwharrie formations of the Albemarle Sequence (**Figure 1** and **Figure 2**). The western deposits in the trend, including the Jones-Keystone, Southern Homestake, Lofflin, Parrish, and Kindley mines are hosted by the Mudstone Member of the Cid Formation. The Hoover Hill, Pierce Mountain, and Sawyer deposits occur in the Tillery Formation. The New Sawyer deposit is hosted by the Uwharrie Formation. Gold mineralization occurs in several clusters and alignments at the western end of the trend, with single deposits spaced 2.5 to 5 kilometers in the central and western portions.

These gold deposits appear to be the result of the interaction of auriferous hydrothermal fluids with a combination of structural controls and favorable lithologies. Northeast-trending shear zones axial planar to meso-scale folds have been recognized as the primary control of gold mineralization at the Lofflin group of mines (**Stromquist *et al.*, 1971**; **Kinkel, 1974**; **Bateson, 1990**; **Lucas, 2013**), the Jones-Keystone Mine (**Stromquist *et al.*, 1971**; **Kinkel, 1974**; **Lucas, 2013**), the Sawyer Mine (MRDS record #10026505, URL https://mrdata.usgs.gov/mrds/show-mrds.php?dep_id=10026505, viewed 01 January 2018), and the New Sawyer Mine (MRDS record #10026503, at URL https://mrdata.usgs.gov/mrds/show-mrds.php?dep_id=10026503, viewed 01 January 2018). Multiple zones of hydrothermal alteration and gold mineralization are typically present at each deposit. They are characterized by narrow, discontinuous, 1-5 meters wide intervals of higher-grade ore (0.25- 0.50 oz/t Au) enclosed by tens of meters of low-grade ore (0.03-0.10 oz/t Au). Historically mined surface and near-surface oxidized ore often averaged 0.20-0.5 oz/t Au.

Hydrothermal alteration and gold mineralization are often most strongly expressed in specific lithologic units, typically finer-grained volcaniclastic and epiclastic sedimentary lithologies. These units may be favored hosts due to compositional, textural, and/or rheological properties. Hydrothermal alteration is dominantly pyritic sericite-rich phyllic assemblages with subordinate silicic alteration, and characterized by intense sulfidation of large volumes of the host protolith. Pyrite formation, locally by replacing pre-existing pyrrhotite, may have been an important mechanism in gold precipitation. Mineral assemblages and rock fabrics associated with mineralization are consistent with synkinematic deformation and regional greenschist facies metamorphism.

The gold deposits of the Sawyer-Keystone trend appears to represent a series of *en echelon* shear zones trending around 040°-060° and axial planar to sets of meso-scale folds that plunge gently northeast. These structures appear to cut across the strike and dip of lithology and overprint an earlier generation of large-scale first-order folds formed during the early phases of the Cherokee Orogeny (**Hibbard *et al.*, 2012**). The absence of a linked, through-going major structure suggests that total strain along the Sawyer-Keystone trend is relatively low. Folding, shearing and faulting associated with this structure may be locally perturbed and deflected by older structures or rheological buttresses, such as the Shepherd Mountain and Caraway Mountain rhyolite magmatic centers.

All known exploration results to date suggest that historic mining of most of these gold deposits benefitted greatly from oxidation of the sulfide ores to a depth of up to 30 meters, resulting in mobilization and aggregation of gold to coarser grain sizes, near-surface supergene enrichment, and residual surface accumulation. These processes were probably facilitated by a long history of temperate climate weathering and acid leaching with the breakdown of the ~5% disseminated sulfides present.

Subsurface drill-hole intersections of primary sulfide mineralization are typically low-grade (0.01-0.03 oz/t Au) intervals meters up to tens of meters wide with localized narrow intervals of higher-grade (0.10-0.25 oz/t Au) mineralization. Much of the higher-grade near-surface oxide ore resource in some deposits was depleted by historic mining. However, a number of deposits have significant potential for large tonnages of easily mined and milled low-grade oxide and transitional oxide-sulfide ore amenable to high rates of Au recovery.

The structural controls of Au-mineralization along the Sawyer-Keystone trend suggest that mineralization post-dates deposition of the Uwharrie, Tillery and Cid Formations during the late Proterozoic, as well as the initial phases of deformation associated with Cherokee Orogeny in the late Ordovician to early Silurian (**Hibbard *et al.*, 2012**). Similar mineralization with similar structural controls is present at the Russell, Coggins, and possibly the Riggon Hill mines in the Ophir District of Montgomery County.

These relatively large tonnage, low-grade Au-Ag-As deposits have distinctive and consistent characteristics that suggest unifying principles of structural and lithologic controls, hydrothermal alteration processes and products, and a similarity in ore-forming fluid character. They are informally designated *Sawyer-type* gold deposits and appear to be possible shallow mesothermal or deep epithermal occurrences that formed synchronously with classic *Gold Hill-type* mesozonal orogenic gold deposits, strongly clustered along the Gold Hill Fault Zone, in the Carolina Terrane of central North Carolina during the Cherokee Orogeny in the late Ordovician (**Hibbard *et al.*, 2012**).

Mines and prospects of the Sawyer-Keystone Trend

The following descriptions of the historic mines and prospects along the Sawyer-Keystone Trend are based on accessible published and unpublished records in the public domain, and on the personal experiences of the author, who visited, mapped, and sampled most of these deposits during the 1970s and 1980s.

New Sawyer (Ross, Powell) Mine (Au-As)

This mine is located about 11 kilometers northwest of Asheboro in north-central Randolph County, North Carolina, and 4.8 kilometers northeast of the Sawyer Mine (**Figure 2**) at geographic coordinates -79.86172, 35.80065 (WGS84). Mining is reported in 1902, but ended when primary sulfides were encountered below the oxidized zone (MRDS record #10026503, at URL https://mrdata.usgs.gov/mrds/show-mrds.php?dep_id=10026503, viewed 01 January 2018).

The mineralized zone is marked by a line of shafts, a series of northeast-trending trenches, and a stope. Several shafts are present, ranging in depth from 9 to 18 meters, with one shaft extending to a depth of 30 meters (MRDS record #10026503, at URL https://mrdata.usgs.gov/mrds/show-mrds.php?dep_id=10026503, viewed 01 January 2018). Drifts oriented 315° are reported at a depth of 9 meters in some shafts, and may be cross-cuts that explored for parallel lodes. Numerous prospect pits and trenches are present peripheral to the main line of workings.

The main ore zone is tabular and averages about 5 meters wide with a strike length of 150 meters (MRDS record #10026505, at URL https://mrdata.usgs.gov/mrds/show-mrds.php?dep_id=10026505, viewed 01 January 2018). Ore minerals at the New Sawyer Mine include pyrite, magnetite, and gold with associated gangue minerals quartz, muscovite, kaolinite, and hematite in a zone of phyllic to silicic alteration (MRDS record #10026505, at URL https://mrdata.usgs.gov/mrds/show-mrds.php?dep_id=10026505, viewed 01 January 2018).

Several mineralized zones in quartz sericite schist are reported on the property, and sampling by H. D. McDonald in 1930 defined two zones of gold mineralization (**Pardee and Park, 1948**). One zone is 1.0-4.5 meters wide and assay values for grab samples collected along strike for 150 meters range from 0.057 to 0.24 oz/t Au, and the second zone showed an average of 0.046 oz/t Au across a width of 26.5 meters (**Pardee and Park, 1948**).

The deposit appears to be hosted by felsic volcaniclastic units of the Uwharrie Formation of the Albemarle Sequence. Structural controls of mineralization appear to be northeast-trending shear zones and associated NE-trending meso-scale folds that plunge to the north (MRDS record #10026503, at URL https://mrdata.usgs.gov/mrds/show-mrds.php?dep_id=10026503, viewed 01 January 2018).

Battle Mountain Gold acquired the property and drilled six shallow RC holes and two shallow core holes at the New Sawyer Mine, with an additional six shallow RC holes completed in 2009 to define a shallow oxide resource (https://www.prnewswire.com/news-releases/romarco-provides-regional-project-update-137473413.html, viewed 01 January 2018). The results of this program are not available. Romarco Minerals Incorporated subsequently obtained the property and drilled six drill-holes in 2012, but the results have never been announced.

Sawyer Mine (Au-Ag-As)

The mine is located 12.5 kilometers northwest of Asheboro and 11 kilometers southwest of Randleman in northwest Randolph Count, North Carolina (**Figure 2**) at geographic coordinates -79.91645, 35.78926 (WGS84). Carraway Creek runs through the property and the line of historic workings is intersected by road SR1004, with open cuts, portals, and drifts extending at least 150 meters to the WSW and ENE (**Carpenter, 1976**). **Pratt (1907)** reports that prospecting along the line of lode may have extended for 2500 meters. This deposit is designated as the type example for this style of gold mineralization in the Carolina Terrane in central North Carolina.

Mining and exploration history

The mine was in operation prior to 1856 (**Emmons, 1856**) with workings along 5-6 parallel zones of strongly foliated Au-bearing silicified schist (**Nitze and Hanna, 1896**). The mine was active in 1902 (**Pardee and Park, 1948**) and a 46 meters deep shaft was completed on the Miller Vein around 1906, with six shallower shafts opened along other lodes (**Pratt, 1907**). The site was inactive by 1913 (**Pratt and Berry, 1919**), but some prospecting was reported as late as 1930 (**Pardee and Park, 1948**).

Several mining companies evaluated the Sawyer Mine during the mid-1970s to mid-1980s, including Phelps Dodge Exploration East, Goldfields, and Nicor. Two drilling programs totaling an estimated 5000 meters were completed by Goldfields and Nicor in the mid-1980s, including 6 core holes and approximately 20 reverse circulation holes. Available assays from the drill-holes include subsurface values of 0.02-0.20 oz/t Au over 0.75 meter intervals (MRDS record #10026505, at URL https://mrdata.usgs.gov/mrds/show-mrds.php?dep_id=10026505, viewed 01 January 2018).

Romarco Minerals Incorporated announced the completion of 5 drill-holes at the Sawyer Mine in 2012 (https://www.prnewswire.com/news-releases/romarco-provides-regional-project-update-137473413.html, viewed 01 January 2018). Multiple intervals of subsurface gold mineralization were intersected, most averaging about 1-3 g/t (0.03-0.09 oz/t) Au over intervals of 1.5-5.0 meters at depths of less than 25 meters. The best result was 10.7 meters (0-10.7 meters down-hole) averaging 4.5 g/t (0.13 oz/t) Au in vertical drill hole HKDH-11-003.

Deposit geology

The mineralized lodes of the Sawyer Mine are developed in metasedimentary rocks of the Tillery Formation and variably described as strongly foliated silicified schists or slates (**Nitze and Hanna, 1896**; **Pratt, 1907**). **Pratt (1907)** noted that portions of the Sawyer lodes were extremely siliceous, including a part of the Miller Vein described as hard, laminated, quartz-rich, and similar to the Big Cut lode of the Russell Mine in the Ophir District in Montgomery County.

The siliceous Brummel Hill lodes at the Sawyer Mine resemble quartzite (**Pratt, 1907**).

Carpenter (1976) interpreted the texture of the alteration zones as mylonite; however, it is more accurately a phyllonite. The presence of small-scale northeast-striking, N-plunging folds that deform quartz veins and stringers within the alteration zones have a left lateral sense of shear (MRDS record #10026505, at URL https://mrdata.usgs.gov/mrds/show-mrds.php?dep_id=10026505, viewed 01 January 2018) and suggest sinistral or possibly oblique brittle-ductile strain within a fault zone that strikes northeast and dips moderately to steeply northwest.

Carpenter (1976) reports gold workings extending along a strike length of about 300 meters, but a total strike length of around 550 meters has also been suggested (MRDS record #10026505, at URL https://mrdata.usgs.gov/mrds/show-mrds.php?dep_id=10026505, viewed 01 January 2018). **Luttrell (1978)** reports that alteration and some surface geochemical anomalies extend for up to 500 meters northeast of the historic mine workings, suggesting a total strike of over a kilometer. **Pratt (1907)** reports that the Miller Vein was mined and prospected for around 2500 meters prior to the Civil War. The width of the Sawyer Mine zone, defined largely by the Miller and Sulphur veins (**Pratt, 1907**), is at least 200 meters. **Luttrell (1978)** reports that mineralized lodes of the Sawyer Mine strike 040° to 052° dip about 45° NW; and Carpenter (1976) states that the Miller Vein strikes 050° and dips 50° NW. However, **Emmons (1856)** reports that the Sawyer lodes strike 050° and dip 75°-80° NW. This may suggest variations in the orientation of structural fabrics among the various mineralized zones.

Major mineralized zones

Historic mining at the Sawyer deposit largely focused along three distinct mineralized zones; the Miller Vein, the Sulphur Vein, and the Davis Vein (**Figure 3**). The Miller Vein may be the lode reported by **Carpenter (1976)** as a mineralized zone that varies from 1.8 to 15 meters thick that averages 4.5 meters thick, and is part of a zone of shearing and alteration up to 30 meters thick. The Miller Vein is reported to occur in the hanging wall of a dark-colored granitic porphyry dike or diabase about 3 meters thick, and to be more siliceous with higher gold grades than the other lodes (**Pratt, 1907**). The vein is reported to average around 0.30 oz/t Au (**Pratt, 1907**). Around 1906, a shaft 46 meters deep intersected the Miller Vein at a depth of 30 meters below surface, with drifts developed for 12 meters NE and SW along strike (**Pratt, 1907**). The shaft intersected the footwall dike at a depth of 33.5-36.5 meters (**Pratt, 1907**).

The Sulphur Vein is located parallel and 183 meters southeast of the Miller Vein, with a mineralized strike length of at least 75 meters and a surface width of 6.7 meters (**Pratt, 1907**). A more strongly mineralized interval 1.8 meters wide within the lode was stoped-out from the surface to a depth of 18 meters along a strike length of 30 meters, with an average grade of $9.20 or 0.45 oz/t Au (**Pratt, 1907**). The lower-grade portion of the Sulphur Vein lode averaged about 0.14 oz/t Au in 75 samples (**Pratt, 1907**).

The Davis Vein is an arcuate 366 meter long mineralized zone in the footwall of the Miller Vein that may represent a splay. The intervening "horse", or block of host rock, is up to 73 meters wide. The Davis Vein is 3.3 meters thick and averages 0.20 oz/t Au in the haulage way cut (**Pratt, 1907**). Soil samples in the horse between the Davis and Miller veins average 0.08 oz/t Au (**Pratt, 1907**). The northeast end of the Davis Vein intersects the Miller Vein in a zone 9.8 meters wide that averages 0.29 oz/t Au (**Pratt, 1907**), but the southern intersection with the Miller Vein was not located. **Luttrell (1978)** suggests that the Davis Vein may be an offset and repeated segment of the Miller Vein.

The Brummel Hill and Old Pace gold prospects are located 60 meters *en echelon* to the east of the strike of the Sulphur Vein (**Pratt, 1907**) and are a probable continuation of the Sawyer Mine mineralized zone. Workings along the irregular, discontinuous lodes of the Brummel Hill Mine occur within a zone 12 meters wide over a strike of 137 meters that dips 45° NW (**Pratt, 1907**). A large open cut at the east end of this zone produced 100 tons of ore at an average grade of 0.12 oz/t Au (**Pratt, 1907**). The Old Pace workings are *en echelon* to the northeast of the Brummel Hill workings, with a zone 1.8 meters wide that assayed up to 0.44 oz/t Au along a strike of 800 meters (**Pratt, 1907**).

Alteration and mineralization

Mineralization at the Sawyer deposit consists of disseminated fine grains and aggregates of pyrite, with euhedral crystals up to 2.5 centimeters diameter in the hanging wall and footwall of the lode (**Pratt, 1907**), although quartz veins and veinlets parallel to foliation are also reported (MRDS record #10026505, https://mrdata.usgs.gov/mrds/show-mrds.php?dep_id=10026505, viewed 01 January 2018). Accessory sulfides include galena, sphalerite, and arsenopyrite with gangue alteration minerals quartz, sericite, and chlorite (MRDS record #10026505, https://mrdata.usgs.gov/mrds/show-mrds.php?dep_id=10026505, viewed 01 January 2018). In core samples from the gold-bearing zones, geochemically anomalous zinc is present at concentrations of up to 4000 ppm and Pb is present at up to 800 ppm (MRDS record #10026505, https://mrdata.usgs.gov/mrds/show-mrds.php?dep_id=10026505, viewed 01 January 2018). The primary geochemical signature of the mineralization appears to be Au-As ± Pb ± Zn; however, no information on trace elements is available.

Pyrite is oxidized to a depth of 24 meters and the ore disintegrates to fine-grained white sand at the surface (**Emmons, 1856**; **Nitze and Hanna, 1896**), suggesting acid leaching through pyrite oxidation. Supergene oxidation and possible secondary enrichment may have been major factors in the economics of historic mining at the Sawyer.

Assays for selected surface rock samples from the lodes generally range from 0.05 to 0.2 oz/t Au (**Luttrell, 1978**). Samples taken from open-cuts and other surface workings (**Pratt, 1907**) assayed $0.80 cents to $14 to the ton gold (0.04 to 0.60 oz/t Au @ $20.67/ounce). Twenty-one samples taken from the Brummel Hill workings in 1936 (**Luttrell, 1978**) contained gold values from a trace to $36.75 per ton (1.05 oz/t Au @ $35 per ounce).

Pierce Mountain Mine (Au)

This prospect is located 13 kilometers northwest of Asheboro (Figure 2) at geographic coordinates -79.93478, 35.76565 (WGS84). The mine was opened by the Pierce Mountain Gold

Mining Company in 1903. Mining was largely alluvial in this area, but an irregular area of rhyolite along the south flank of the Shepherd Mountain intrusive-extrusive center is intensely silicified with small (≤ 1 millimeter) stockwork quartz veinlets and disseminated pyrite. Grab samples of the mineralization, assayed by Phelps Dodge Exploration East, contained up to 0.5-1.5 g/t (0.01-0.04 oz/t) Au. In an interview in 1981, the property owner recalled small-scale placer operations on the property, but had no knowledge of any lode mining or prospecting.

The Jericho Hill project area of the Revolution Resource Corporation covers the general area a kilometer south of the Pierce Mountain Mine, where a series of rhyolite intrusive-extrusive complexes, including Shepherd Mountain and Caraway Mountain, intrude the Tillery Formation (**Lucas, 2013**). Volcaniclastic and metasedimentary units of the Tillery Formation are the host lithologies in the project area. The metasediments are dominantly siltstone and sandstone but include units of graywacke up to 30 meters thick (**Lucas, 2013**).

Two generations of quartz veins are hosted largely by volcaniclastic rocks; an older, strongly deformed and unmineralized set of veins, and a younger, weakly deformed set that carry gold mineralization (**Lucas, 2013**). Alteration is generally weak chlorite and sericite, with strong silicic alteration of selected units and intervals, especially tuffaceous units (**Lucas, 2013**).

Mineralization consists of quartz veins with pyrite + chalcopyrite + an unidentified telluride mineral, and pyrite and chalcopyrite also occur as disseminated grains peripheral to the veins (**Lucas, 2013**). Abundant pyrrhotite is locally present in the tuffaceous units, the preferred host for gold mineralization (**Lucas, 2013**).

Geologic mapping, rock chip and soil sampling, and 16 drill holes totalling 2882 meters were completed across this property in 2011. A total of 29 rock chip samples from outcrop, subcrop, and float returned assay values ranging from 0.01-6.23 g/t (<0.001-0.18 oz/t) Au (**Lucas, 2013**). Drill holes targeted the subsurface extension of Au-Ag bearing surface rock samples and an Au-Ag-Te soil anomaly. Drill-hole JH11-001 intersected 22 meters (28.5-51.0 meters down-hole) that averaged 6.10 g/t (0.18 oz/t) Au and 258.65 g/t (7.55 oz/t) Ag, including 7.9 meters of 16.06 g/t (0.47 oz/t) Au and 698.66 g/t (20.38 oz/t) Ag (**Lucas, 2013**). Other drill holes were either barren of intersected only narrow intervals of low-grade mineralization.

Hoover Hill Mine (Au-Ag)

The mine is located about 19 kilometers northwest of Asheboro and 27 kilometers southeast of High Point on the east side of the Uwharrie River (**Figure 2**) at geographic coordinates -79.97284, 35.75148 (WGS84).

Mining and exploration history

The deposit was discovered by Joseph Hoover in 1848 and worked briefly before being sold to McDowell, Woodfin, and Avery (**Pardee and Park, 1948**). They worked the mine for several years and leased parts of it to tributors (contract miners), but work soon ceased. The mine was purchased by the Hoover Hill Gold Mining Company Limited of London in 1881, which installed a steam powered 20-stamp mill and worked the deposit until 1895 (**Pardee and Park,**

1948).

The gold ore bodies were mined through five shafts during this period; the Briols, Gallimore, Hawkins 1, Hawkins 2, and Provost. Seven small surface pits were also in operation. Mine closure has been attributed to the death of the company president and subsequent improper management. High-grading by the acting mine superintendent depleted remaining reserves, mining ceased, and the equipment was sold (**Lucas, 2013**).

The mine was purchased in 1907 by L. A. Briols (Briles). A small amount of ore was produced in 1914 and 1917, but after 1922 the mine was allowed to flood. In 1936, the Keystone Mining Company planned to dewater the mine shafts and use the water to hydraulic mine the hillsides, but this did not occur (**Luttrell, 1978**).

Gold production from May 1881 to June 1895 is recorded as $300,000, about 14,513 ounces of gold (**Nitze and Hanna, 1896**). Production for the period 1848 to 1881 is estimated at $50,000, or about 2419 ounces of gold, for a total estimated gold production of around 16,932 ounces (**Nitze and Hanna, 1896**).

Like all gold deposits in the district, the Hoover Hill Mine was visited and evaluated by several mineral exploration companies from 1975 to 1991. The property was leased in 1982 by the Piedmont Land and Exploration Company, but no record of their work is available. Revolution Resources Corporation conducted additional geologic mapping and soil and rock sampling in 2010-2011 and drilled two core holes in 2011 that totaled 439 meters (**Lucas, 2013**). One hole intersected narrow (2 meters) intervals of weak (1-2 g/t or 0.03-0.06 oz/t) Au mineralization.

Deposit geology

The host rock is reported as dark-gray, variably quartz- and feldspar-phyric rhyolite intruding the Tillery Formation, and containing phenocrysts of glassy quartz and dull white feldspar (**Pardee and Park, 1948**). **Nitze and Hanna (1896)** suggest that the host rock is variably schistose, partially brecciated "basic eruptive" with clasts of hornstone (cherty rhyolite). **Lucas (2013)** reports that the host rocks of the deposit are mafic flows, volcanoclastic units, and porphyritic dykes. No rhyolite flows were encountered at the surface or in drill-holes, but brecciated volcanoclastic intervals with tuffaceous and metasediment fragments are reported (**Lucas, 2013**).

The Hoover Hill Mine falls within a localized unit mapped by **Seiders (1981)** as "pebbly mudstone and mudstone conglomerate". It consists largely of angular to rounded pebbles and cobbles of mudstone in a mudstone matrix and also contains clasts of rhyolite. **Seiders (1981)** suggests that this unit may have formed synchronously with emplacement of the adjacent Shepherd Mountain rhyolite dome. This unit, intruded by rhyolite dikes, is consistent with the host rocks interpreted from surface mapping and drill holes as reported by **Lucas (2013)**.

Major ore bodies

At least six mineralized zones with a maximum width of 4.6 meters are present; each strikes about 040° and dips 30°-60°NW, but they form an alignment trending 320° (MRDS record #10026506). The ore bodies are characterized by sheared, brecciated, and altered rocks with about 3 vol% disseminated pyrite, and cut by sets of reticulated quartz veins 2.5-30 centimeters thick (**Nitze and Wilkens, 1897**). These veins may be zoned with open space filling textures, and may form composite veins that contain potassium feldspar (MRDS record #10026506, URL https://mrdata.usgs.gov/mrds/show-mrds.php?dep_id=10026506, viewed 01 January 2018).

Not all quartz veins in the deposit are mineralized. Most are white and opaque, but transparent and bluish green quartz veins are associated with the richest gold ore (**Nitze and Hanna, 1896**). The gold is free-milling and typically fine-grained or "dust" concentrated at the contact between quartz veins and the host rock (**Nitze and Hanna, 1896**). Surface outcrops of the lodes were highly enriched in gold.

The principal ore body is the Briols Shoot, worked through the Briols Shaft and the inclined Gallimore Shaft, one of three stopes that extended to the surface from the Briols Shaft (**Nitze and Hanna, 1896**). The Briols Shaft was 107 meters deep with working levels at 21, 40, 52, 70, 91, and 107 meters (**Pardee and Park, 1948**). On the 107 meter level, the Briols Shoot ore body was 21 meters long and 3.7 meters wide and assayed $8 to $10 per ton (0.39-0.48 oz/t Au).

At the 40 meters level of the Briols Shaft, a cross-cut 61 meters long connected to the Provost ore body, worked on a drift 15 meters long, a raise 3 meters high, and a winze 17 meters deep (**Nitze and Hanna, 1896**). The Provost ore body was a quartz stringer zone 40.6-46.0 meters thick (**Nitze and Hanna, 1896**). A cluster of six small orebodies were mined through the Hawkins Shaft, which was 46 meters deep in 1888 (**Kerr and Hanna, 1888**).

Alteration and mineralization

The highest grade ores occurred in pockets and steeply north-dipping chimney-like shoots (**Nitze and Hanna, 1896**). Reported ore minerals include pyrite with minor to trace sphalerite, bornite, galena, and gold (electrum) with gangue alteration minerals biotite, chlorite, and quartz and potassium feldspar (MRDS record #10026506, URL https://mrdata.usgs.gov/mrds/show-mrds.php?dep_id=10026506, viewed 01 January 2018). This record is based on the reporting of **Carpenter (1976)**. However, **Nitze and Hanna (1896)** and **Pardee and Park (1948)** state that pyrite is the only sulfide present. The report of base metal sulfides in the Hoover Hill mineralization appears to be erroneous.

Wilson Kindley Mine (Au)

The mine is located about 19 kilometers northwest of Asheboro and 800 meters southwest of the Hoover Hill Mine (**Kerr and Hanna, 1888**). There is no USGS MRDS record or location for this mine. The mine was worked for a few months in 1881 by a New York company. Workings consisted of one adit and a 12-meter deep shaft. This mine is reported to be located in siliceous rhyolite, similar to host for the Hoover Hill Mine; however, no quartz veins were observed (**Luttrell, 1978**). The property owner claimed in 1934 that gold reportedly found there was salted from the Hoover Hill mine (**Luttrell, 1978**).

Kindley Mine (Au)

The mine is located 18.5 kilometers west of Asheboro in northwestern Randolph County, about 1.1 kilometers south of the Jones-Keystone mine and about 500 meters northeast of the Parish Mine (**Figure 2**), at geographic coordinates -80.007, 35.73037 (WGS84). Little information is available on the geology or the mining history.

The host rock is reported as felsic volcanic units of the Mudstone Member of the Cid Formation (MRDS record #10026509, URL https://mrdata.usgs.gov/mrds/show-mrds.php?dep_id=10026509, viewed 01 January 2018).

Several shallow pits and trenches were present in the mid-1970s, opened along a zone of weathered, Fe-stained sericite-quartz schist with voids after pyrite (**Carpenter, 1976**). A strong foliation strikes 040° and dips 80° northwest (**Carpenter, 1976**).

Parish (Kindley, Kismet) Mine (Au)

The mine is located 18.7 kilometers west of Asheboro in northwestern Randolph County, about 1.1 kilometers south of the Jones-Keystone mine and about 500 meters southwest of the Kindley Mine (**Figure 2**) at geographic coordinates -80.01398, 35.72729 (WGS84). The mine was first worked before 1896; and reopened in 1903 and again in 1929, 1930, and in 1931 (**Luttrell, 1978**). A series of seven shafts are present at the site; the deepest is the Robbins Shaft at about 21 meters (**Carpenter, 1976**).

The host rocks have been reported as decomposed schist, derived from altered andesitic tuff of the Mudstone Member of the Cid Formation (**Luttrell, 1978**). Alteration is described Fe-stained and containing abundant hornblende/actinolite or chlorite (**Kerr and Hanna, 1888**), and Luttrell (1978) reports the presence of pyrophyllite. Ore minerals are listed as pyrrhotite and pyrite. Two grab samples from the wall of the shaft contained 0.72 oz/t Au and 4.28 oz/t Au (**Kerr and Hanna, 1888**). **Pratt (1904)** reports a vein a meter thick composed largely of actinolite with free-milling gold that assayed 0.97-1.45 oz/t Au.

Jones-Keystone Mine (Au-As)

The mine is located 29 kilometers east-southeast of Lexington, 19 kilometers south-southeast of Thomasville, and 19 kilometers west of Asheboro on the west side of the Uwharrie River (**Figure 2**) at geographic coordinates -80.02061, 35.73842 (WGS84). Visible mine workings include two large open cuts (**Figure 4**), several shafts of uncertain depth, remnants of two Chilean mills, and evidence of cyanide vats (**Pardee and Park, 1948**).

Historic mine workings and major lodes

Highly variable gold mineralization is widespread, but economically minable grades were concentrated in two NE-trending zones, described as 33 meters wide and 15 meters, respectively

(**Pardee and Park, 1948**). These zones were exploited by open cast workings named the Big Cut and the Southeast Cut (**Figure 4**).

The Big Cut is about 18 meters wide and 45 meters long, and opened in a zone of mineralization up to 33.5 meters wide. The Southeast Cut is about 9 meters wide, 30 meters long, and opened on a zone of mineralization up to 15 meters wide. The ore bodies are characterized as silicified and Fe-rich schist (**Pardee and Park, 1948**) and described **by Emmons (1856)** as "a mass of soft reddish talcose slate through which gold was disseminated”. Only the relatively weathered and readily disaggregated ore was mined, with “horses” or “bars” of relatively fresh pyritic silicic alteration left as inliers unless of very high grade (**Pardee and Park, 1948**). Zones of barren or very low grade material are also present. In 1856 the working face of the ore zone in the Big Cut was 18 meters wide, up to 9 meters high, and averaged 0.15 oz/t Au (**Pardee and Park, 1948**).

The grade of the historically mined ore shows great variation but typically averages above 0.15 oz/t Au (**Nitze and Hanna, 1896**). Fifteen samples assayed by **Nitze and Hanna (1896)** ranged from 0.10 to 0.30 oz/t Au, with one sample that assayed 1.4 oz/t Au. The ore zone mined by open cut in 1894, probably the Southeast Cut, was 3.7-4.6 meters wide and averaged 0.10 oz/t Au (**Nitze and Hanna, 1896**).

Mining and exploration history

The mine was in operation by 1852 and equipped with a 40-stamp mill, probably one of the first in North Carolina, a 30-horsepower steam engine, 30 washing bowls, and a shaking table (**Pardee and Park, 1948**). A 100 meter rail line connected the open cut mines to the mill. Concentrates from the washing bowls formed less than 1% of the processed ore, and recovery was low due to the fine-grained character of much of the gold (**Pardee and Park, 1948**). The mine was closed during the Civil War (1861-1865), but was reopened in the late 1870s and operated for short periods in 1880, 1884, 1894, 1895, 1896, and 1903 (**Luttrell, 1978**).

The 40-stamp mill from the Coggins Mine in the Ophir District of Montgomery County, North Carolina, was moved to the Jones mine in 1896 (**Luttrell, 1978**). The Keystone Mining Company operated the mine around 1936 and processed several hundred tons of ore averaging 0.09 oz/t Au (**Bryson, 1936**). As near-surface oxidized ore in the two main ore zones was depleted and primary sulfide ore was encountered at depth, the value of the ore decreased and the mine was abandoned (**Luttrell, 1978**). It is estimated that a total of between 30,000 and 40,000 tons of material were excavated from the two main open cuts (**Pardee and Park, 1948**). According to **Pardee and Park (1948)**, milling of all of the mined material would yield a total estimated gold production of around 5000 ounces. However, accurate figures for total gold production from the mine are not available.

Asarco Exploration leased the Jones-Keystone in 1969, and conducted soil sampling, trenching, and drilled three diamond drill-holes totaling 454 meters. Cyprus Mines and Louisiana Land and Exploration held the property in 1975-1976. Piedmont Land and Exploration Company then held the property from 1981-1991 and completed additional surface sampling, two new surface trenches, and drilled one diamond drill hole to a depth of 154 meters. Numerous mining companies, including Noranda, Phelps Dodge, and BP Minerals examined the property and worked in the surrounding region during this time.

Revolution Resources Corporation completed additional geologic mapping, soil and rock sampling, and a ground magnetic survey in 2010-2011. Forty eight drill holes totaling 10,442 meters were completed during this period along 1000 meters of strike, many intersecting the mineralized zones at depths of 100 to over 300 meters down-hole (**Lucas, 2013**). These drill holes commonly intersected mineralized intervals 10-40 meters wide (in-hole) that assayed 0.01-0.04 oz/t Au and often contained 5-10 meter intervals of higher grade mineralization (**Lucas, 2013**). Drill-hole JK10-006 under the old workings intersected 54 meters of mineralization averaging 0.04 oz/t Au, including 28 meters at 0.09 oz/t Au and 2 meters of 0.27 oz/t Au.

Deposit geology

Regionally, the deposit is hosted by interbedded basaltic to andesitic flows and volcaniclastic units, felsic intrusives, and mudstone-siltstone-graywacke turbidite metasediments of the Mudstone Member of the Cid Formation. The area lies on the northwest limb of the Denton Anticlinorium, formed during the early phases of the Cherokee Orogeny in the late Ordovician (**Hibbard *et al.*, 2012**). The anticlinorium broadens and flattens in this area and the strike of the axial plane turns from NE to ENE. **Carpenter (1976)** suggests that the host for mineralization is sheared felsic volcanic rocks. **Lucas (2013)** reports that the primary host is a volcaniclastic sequence with thin interbedded mafic flows.

Stromquist *et al.* (1971) locate the Jones-Keystone and Lofflin Mines on a northeast-trending shear zone. Working with **Kinkel (1974)**, Stromquist suggested that this shear zone cut across lithology, with mineralization developed where the structure intersected favorable host rocks. **Lucas (2013)** suggests that there are two distinct episodes of meso-scale folding present at the Jones-Keystone deposit. The older fold axes are oriented east-west, while the younger fold axes strike northeast about 055° and dip steeply northwest (**Lucas, 2013**).

The available geologic data and outcrop patterns on the geologic map of **Lucas (2013)** do not convincingly support the presence of older east-west striking folds. The plunge of the younger NE-trending folds is around 10°-12° SW, but changes where they intersect the axes of older folds (**Lucas, 2013**). **Lucas (2013)** interprets the dominant meso-scale fold in the area of mineralization (**Figure 5**) as a syncline, possibly flanked by narrow, strongly appressed, low amplitude anticlines. However, available data are not sufficient to confirm this interpretation. The geometry of mafic flow units in a drill-hole cross-section located southwest on strike from the historic mine working (**Figure 6**) is consistent with the presence of a steeply northwest-dipping reverse shear zone along the northwest limb of the syncline, which appears to be overturned to the southeast.

Alteration and mineralization

There is extensive weak pervasive chlorite alteration, and more localized areas of pyritic phyllic and silicic alteration associated with zones of strong penetrative foliation axial planar to the meso-scale northeast striking folds (**Lucas, 2013**). Some specimens of ore from the Southeast Pit are strongly pyritic and others are reported as composed largely of pyrophyllite (**Pardee and Park, 1948**), although this is more likely to be sericite.

The foliation typically strikes 045° and dips 80° NW (**Nitze and Hanna, 1896**, **Pardee and Park, 1948**) but the strike varies from 040° to 060° (**Kerr and Hanna, 1888**). The ore zones are characterized by the presence of numerous thin (millimeter-scale) quartz veinlets and stringers sub-parallel to cleavage and striking 030° to 048° (**Nitze and Hanna, 1896**; **Carpenter, 1976; Lucas, 2013**). Pyrite + pyrrhotite ± arsenopyrite occur as disseminated grains and in irregular to cleavage-parallel quartz veins, veinlets, and stringers (**Lucas, 2013**). Mineralization appears to be preferentially developed in volcaniclastic units and is more weakly developed in mafic flows and siltstone-shale intervals (**Lucas, 2013**).

The Southeast Cut and the eastern portion of the Big Cut (**Figure 7**) were extensively sampled in 1966 (**Kinkel, 1974**). A total of 64 channel samples ranging in length from 0.6 to 3 meters were collected from the pit walls and from several "horses" within the pits; many samples a mixture of soil and saprolite. Most samples assayed less than 1 g/t Au (0.03 oz/t); however, 13 samples ranged between 1.0 g/t Au (0.03 oz/t) and 2.5 g/t Au (0.07 oz/t) and three samples contained greater than 4.5 g/t Au (>0.13 oz/t) with a high value of 18.5 g/t Au (0.54 oz/t).

Arsenic was strongly anomalous in most samples, commonly exceeding 300 ppm, and 9 samples contained in excess of 1000 ppm As with a high value of 2400 ppm As (**Kinkel, 1974**). There is no direct correlation between concentrations of gold and arsenic in the samples. Copper is weakly to moderately anomalous, with 16 samples ranging from 100 to 1000 ppm and a high value of 1800 ppm Cu. Zinc is weakly anomalous in 7 samples with a range of 100-200 ppm, and Pb and Mo are at background values (**Kinkel, 1974**). Arsenic is clearly introduced during the gold mineralizing event; however Cu and Zn could be inherited from alteration and sulfidation of the mafic volcaniclastic protolith.

Historic mining of the Jones-Keystone deposit benefitted from the oxidation and easy disaggregation of gold mineralization to a depth of around 30 meters, probably enhanced by near-surface dissolution and precipitation of gold at larger grain size and higher fineness. Available surface and subsurface data do not suggest that the available resource at the Jones-Keystone Mine is a viable target for modern mining; however, there is a potential to develop additional targets in alteration zones along and across strike.

Southern Homestake Mine (Au)

The mine is located about 21 kilometers west of Asheboro near Lytton in the Tabernacle Township in northwestern Randolph County, 5.6 kilometers northwest of Jackson Creek, and about 1.5 kilometers west of the Jones-Keystone Mine (**Figure 2**), at geographic coordinates -80.03784, 35.73787 (WGS84). Most of the work on the property was around 1910 (**Carpenter, 1976**).

The Southern Homestake Mining Company worked free-milling gold from a series of parallel zones of schistose mineralization (**Pratt, 1904**). One of the "veins" with ore that averages 0.15-0.24 oz/t Au was exposed in a series of open cuts and shafts to depths of 8-15 meters for a distance along strike of around 370 meters (**Pratt, 1904**).

Workings in 1904-1906 included a 16-meter deep shaft, two cross-cut trenches, a tunnel, and open cuts extending for a distance of 365 meters along strike (**Luttrell, 1978**). A cyanide mill installed circa 1904 treated only 150 tons of ore and was abandoned. The last work recorded on the site was in 1923. In 1968, remaining workings included three pits measuring 6 x 6 meters and 3 meters deep, possibly collapsed shafts, a 60 meter cross-cut trench 1.5 meters wide and a meter deep oriented 330°, and a few pits (**Carpenter, 1976**).

Luttrell (1978) reports that free milling gold ore occurs in parallel bands or veins in a schistose zone developed in black porphyritic rhyolite breccia. The alteration zone is silicified to sericitic and Fe-stained with limonite after pyrite grains (**Carpenter, 1976**).

Cameron Mountain Mine (Au)

This mine is reported to adjoin the Southern Homestake Mine (**Luttrell, 1978**). The ore is part of a zone of silicified sheared schist and was mined from open pits and shafts up to 38 meters deep in 1903 (**Pratt, 1904**). Most of the ore probably was taken from a group of pits up the hill from the main shaft (**Luttrell, 1978**). The last recorded work on the site was a placer operation in 1923.

Senter Mine (Au)

The identity and location of the Senter Mine, located somewhere near Lytton in northwest Randolph County, is uncertain. It is mentioned by **Pratt (1904)** and is separate and distinct from the Southern Homestake Mine, Cameron Mountain Mine, Lofflin (Empire) Mine, Parish Mine, and Jones-Keystone Mine. No other source of information has been found.

Pratt (1904) reports that two parallel veins or bands of auriferous schistose rock have been prospected for a distance of around 1200 meters along the strike through a series of open cuts, shallow pits, and short drifts, with one shaft that reaches a depth of 21 meters (**Pratt, 1904**). The width of this gold-bearing zone ranges from 30-90 meters (**Pratt, 1904**) and averages 0.14-0.24 oz/t Au (**Luttrell, 1978**).

Lofflin (Lafflin, Laughlin, Empire, Herring) Mine, Delph (Delft, Delk) Mine, Miller Mine, and Brown Hill Mine (Au)

This cluster of four or more small historic mines and prospects is located 21 kilometers west of Asheboro and 4 kilometers northwest of Jackson Creek in northwest Randolph County, North Carolina (**Figure 2**). The Lofflin Mine is located at geographic coordinates -80.04117, 35.72065 (WGS84). The geologic controls and mineralization are similar to those of the Jones-Keystone Mine to the northeast; but multiple, discontinuous, possibly *en echelon* mineralized structures are present over a zone 1.6 kilometers wide (**Figure 8**). Historic mine workings are scattered over a broad area, but the most extensive workings occur at the Lofflin, Delk, and Brown mines (**Bateson, 1990**).

Mining and exploration history

Little information is available regarding the early history of mining at these deposits or the amount of gold produced; however, the extent and volume of mining and processing suggest minor total production. The mine was in operation during the 1850s and production may have peaked in the early 1880s (**Bateson, 1990**). There was also activity during 1907 (**Pratt, 1907**) and in 1933-1934.

While the mine was operated by the Empire Mining Company in 1907, there was an evaluation of gold distribution using pan assays of samples from the surface and cross-cut trenches by Mr. McCutcheon and Mr. Gaiford (**Pratt, 1907**). They defined two belts of mineralization 60 meters wide and 800 meters long, characterized by “argillaceous slates full of casts of pyrite quite uniformly distributed along the bedding plane”. These are interpreted as zones of strongly foliated phyllic to silicic alteration with disseminated pyrite, variably weathered and partly disaggregated by acid leaching. **Emmons (1856)** described the ore as similar to impure porcelain clay or a “pasty mass” to a depth of 12 meters, and noted that higher gold values occurred with “black sand”. Pyritic sericite schist was encountered in a shaft at a depth of 21 meters in one of the mineralized zones (**Pratt, 1907**). The penetrative cleavage in the mineralized zones strikes 045° and dips steeply northwest.

The north side of the northwest belt of Au mineralization is in contact with a zone of intense silicification, and the northeastern end of the belt is extensively worked by old open cuts and adits on Kern Hill (**Pratt, 1907**). These include a large open cut about 23 meters wide and up to 15 meters deep that produced ore grading 0.29 to 0.34 oz/t Au (**Pratt, 1907**). High-grade ore was selectively mined from irregular workings in the northeast corner of this pit (**Pratt, 1907**). A drift extends 075° for 30 meters from the pit, where a cross-cut through 15 meters of mineralization averages 0.07 oz/t Au (**Pratt, 2007**). Historic mine workings suggest that the northwest gold belt is around 60 meters wide and the mineralization oxidized and weathered to a depth of at least 15 meters (**Pratt, 1907**).

Cyprus Mines and Louisiana Land and Exploration held the property in 1975 and 1976, but conducted only limit exploration. New Jersey Zinc drilled at least eleven air rotary holes to a depth of about 30 meters near the old workings in 1981, but results were hampered by ground water encountered at a depth of 10 meters (**Bateson, 1990**). Phelps Dodge conducted surface sampling and geophysics in 1985, and Carolina Resources drilled three rotary holes to around 50 meters depth near the old workings in 1988. A drill-hole was angled -45° to the west under a 12-meter wide surface zone of 1.0 g/t (0.029 oz/t) Au, and averaged 0.985 g/t (0.028 oz/t) Au over 85 meters that included a 1.5 meter interval of 3.58 g/t (0.104 oz/t) Au near the top of the hole (**Bateson, 1990**).

In 1989-1992, Noranda Exploration Incorporated completed mapping, soil surveying, and channel sampling of the historical workings; and drilled 20 diamond core holes (**Bateson, 1990**). Revolution Resources Corporation completed additional geologic mapping and soil and rock sampling, and drilled an additional 27 drill holes totaling 4720 meters in 2010-2011.

Soil sampling by Noranda Exploration (**Bateson, 1990**) defined a zone of 0.2 to 1.5 g/t

(<0.001-0.04 oz/t) Au values that is up to 90 meters wide and strikes northeast for 488 meters at an acute angle to cleavage (**Bateson, 1990**). This may be correlative with the northwest zone of surface mineralization reported by **Pratt (1907)**. Other zones of anomalous soil gold values are irregular and associated with historical mine workings that have extensive surface contamination (**Bateson, 1990**).

Noranda Exploration confirmed the presence of broad intervals of anomalous surface Au values by channel sampling, including 122 meters that averaged 0.03 oz/t Au in a trench across the main soil Au anomaly (**Bateson, 1990**). The eastern 30 meters of this zone averaged 0.044 oz/t Au. A second trench, located 120 meters to the east, averaged 0.028 oz/t Au over 37 meters on the margin of the soil anomaly (**Bateson, 1990**).

Sampling across other areas of historic workings of the Lofflin Mine returned intervals of 6 to 18 meters averaging 0.03 oz/t Au, with similar results from the Delk and Brown mines (**Bateson, 1990**). Similar results were not obtained from drill holes beneath the Lofflin soil and rock chip anomalies, which yielded only 14 meter intervals of 0.01 oz/t Au (**Bateson, 1990**). Results suggest that the mineralization occurs in discontinuous pods or lenses (**Bateson, 1990**).

Deposit geology

The Lofflin deposit is hosted by the Mudstone Member of the Cid Formation on the western limb of the Denton Anticlinorium. **Bateson (1990)** reports that the Lofflin area geology is dominated by andesitic debris flows interbedded with two units of bedded felsic crystal tuff (**Figure 7**), each over 30 meters thick. The sequence strikes approximately north-south and dips about 30° to the west.

Lucas (2013) also notes the presence of often amygdaloidal flows of basaltic to andesitic composition within the mafic volcaniclastic sequence, with amygdules up to 5 millimeters in diameter forming up to 5-7 vol% of the rock. Metasedimentary units are siltstone or mudstone that locally grade into intervals of greywacke (**Lucas, 2013**).

The felsic crystal tuff units (**Figure 7**) are the preferred host for Au-mineralization (**Bateson, 1990**; **Lucas, 2013**) and contain lenses of pumice breccia and horizons with up to 15% pyrrhotite as disseminations, bedding-parallel laminae, and cross-cutting veinlets (**Bateson, 1990**). Pyrrhotite is replaced by pyrite in zones of gold mineralization, and **Bateson (1990)** suggests that sulfidation of pyrrhotite may have facilitated gold deposition.

Stromquist *et al.* (1971) located the Jones-Keystone and Lofflin Mines on a northeast-trending shear zone. **Kinkel (1974)** quotes Stromquist's suggestion that this shear zone cuts across lithology, with mineralization developed where the structure intersected favorable host rocks. **Bateson (1990)** suggests that the controls of mineralization a the Lofflin Mine are the intersection of a series of cleavage-parallel fault structures, striking around 070° and dipping steeply northwest, with the two units of felsic crystal tuff about 30 meters thick that strike north-south and dip 30° west (**Figure 7**). Up to six parallel, discontinuous, possibly *en echelon* northeast-striking structures may be present in a zone up to 1.6 kilometers wide in the Lofflin Mine area. Deformation within these structures appears to be relatively low-strain, dominated by pure shear, with shortening and possible pressure solution perpendicular to cleavage (**Bateson,**

1990). Zones of gold mineralization appear to be lensoidal and discontinuous.

Lucas (2013) suggests that there are two distinct episodes of meso-scale folding at the Lofflin Mine, similar to that described for the Jones-Keystone deposit. The older fold axes are oriented east-west and younger fold axes strike northeast about 045°, dip steeply northwest, and plunge at 3°-4° to the northeast. The penetrative cleavage associated with hydrothermal alteration and gold mineralization is axial planar to the younger fold axes (**Lucas, 2013**). Undulating patterns in the outcrop of lithologic units is the result of interference between these fold patterns and most strongly expressed where the fold axes intersect. Gold mineralization at the Lofflin Mine is confined to the felsic tuff unit in a large NE-striking syncline (**Lucas, 2013**).

While the stratigraphic and lithologic observations of **Bateson (1990)** and **Lucas (2013)** are similar, the structural interpretations are difficult to reconcile. The two sets of meso-scale folds described by **Lucas (2013)** are not recognized by **Bateson (1990)**. Undulating patterns in outcropping lithologies may result from small-scale offsets of north-striking units along NE-trending faults. However, the geologic map of **Bateson (1990)** covers a broad area that encompasses several historic mines, while the work of **Lucas (2013)** is focused on the Lofflin Mine. The presence of NE-trending meso-scale folding associated with zones of shearing, faulting, and intense cleavage development at the Lofflin Mine would be consistent with structural architecture noted at the Jones-Keystone Mine (**Lucas, 2013**) and the Sawyer Mine (MRDS record #10026505, https://mrdata.usgs.gov/mrds/show-mrds.php?dep_id=10026505, viewed 01 January 2018). Offset of lithology along these shear zones would be consistent with the geologic interpretation of **Bateson (1990)**.

Alteration and mineralization

Sericite-rich phyllic and silicic alteration are largely localized to the intersection of cleavage-parallel structures with the felsic tuff units (**Bateson, 1990**; **Lucas, 2013**). Fuchsite is reported in small patches in altered mafic rocks and in the selvages of quartz veins (**Lucas, 2013**). Gold mineralization typically occurs in strongly foliated phyllic and silicic alteration zones with up to 5% total sulfide (**Lucas, 2013**). Sulfides are pyrite > arsenopyrite > pyrrhotite, with pyrrhotite generally absent in higher Au-grade zones (**Lucas, 2013**).

Extensive rock chip and soil sampling by Noranda (**Bateson, 1990**) indicate a strong correlation between Au and As and possibly with Sb. Anomalous As values in mineralized samples commonly range from 200-5000 ppm. Anomalous Sb values in mineralized rock samples commonly range from 10-25 ppm, and locally appear to correlate with weakly anomalous Pb values of 10-40 ppm and possibly anomalous Tl. Silver is virtually absent in the analyses.

Rock sample #5005 is high-grade Au ore that contained 19.93 g/t Au (0.58 oz/t) with 100,000 ppm As and 105 ppm Sb (**Bateson, 1990**). Rock samples A890659C through A890659T, collected across a single mineralized zone, contained Au values of 0.9-5.8 g/t Au (0.03-0.17 oz/t), As values of 1000-6000 ppm, 10-40 ppm Pb, 10-30 ppm Sb, and Tl values of 10-50 ppm. The geochemical signature of the Lofflin area mineralization is interpreted as Au-As-Pb-Sb-Tl; although only arsenic occurs in high enough concentrations to form a useful pathfinder.

The distribution of hydrothermal alteration and associated gold mineralization is highly irregular across the area, but consistently associated with strong cleavage development, which strikes 070° and dips steeply northwest (**Bateson, 1990**). Soil geochemical anomalies are coincident with areas of historic mine workings and occur within the crystal tuff units. A soil anomaly of 0.20-1.5 g/t Au (0.006-0.044 oz/t) is up to 90 metres wide and trends about 050°, oblique to cleavage, for 490 meters. Core drilling below surface anomalies centered on historic workings were generally disappointing, returning more narrow intervals of generally low gold values.

Anomalous As is typically correlative with Au, but two styles of mineralization were noted. Gold + arsenic is associated with strong sericite-rich pyritic phyllic alteration in zones of intense cleavage development, but stockwork quartz-sulfide veins in relatively unaltered rocks peripheral to these zones carry anomalous Au without As (**Bateson, 1990**). Drilling results support the suggestion that Au-mineralization is controlled by the intersection of steeply NW-dipping structures parallel to foliation with favorable lithologies, specifically the two crystal tuff units. However, mineralization within the areas of favorable intersection is discontinuous.

Discussion

Many gold deposits along the Sawyer-Keystone Trend in northwest Randolph County, North Carolina appear to share similar structural controls, character of alteration and mineralization, ore mineralogy, and trace element associations. The deposit character is best represented by the largest, most significant occurrences; including the New Sawyer Mine, the Sawyer Mine, the Jones-Keystone Mine, and the Lofflin Mine. The Southern Homestake, Parish, Kindley, and Pierce Mountain mines are minor occurrences, often formed in host rocks that are atypical of those hosting the major deposits. The Hoover Hill Mine is also an atypical deposit, with structural controls and character of alteration and mineralization different from the major deposits.

The characteristic controls for the Sawyer-Keystone Trend deposits are dominantly structural; consisting of multiple, discontinuous, and possibly *en echelon* ductile-brittle deformation zones that strike 040°-060° and dip steeply northwest. These deformation zones are relatively low-strain and characterized by NE-trending meso-scale folds with axial and possibly limb zones of intense, penetrative cleavage development and shearing typically meters to tens of meters wide. Evidence of sinistral shear sense in north-plunging meso-scale folds at the Sawyer Mine (MRDS record #10026505, https://mrdata.usgs.gov/mrds/show-mrds.php?dep_id=10026505, viewed 01 January 2018) suggests sinistral or possibly oblique brittle-ductile strain along the host structures. The generally gentle NE to SW plunge of meso-scale fold axes in the Jones-Keystone and Lofflin mine areas (**Lucas, 2013**) may suggest dominantly reverse displacement along these fault zones.

Domains of heterogeneous ductile-brittle to brittle strain subparallel to cleavage form pathways for hydrothermal fluids with resulting phyllic to silicic alteration. Mineralization is more strongly developed and more likely to reach economic grade and tonnage in favorable host lithologies. The suitability of these units may be a combination of texture, composition, and rheological properties. At the Lofflin Mine, the favorable host is 30 meters thick units of bedded felsic crystal tuff (**Bateson, 1990**, **Lucas, 2013**) that contain intervals with up to 15% pyrrhotite as disseminations, bedding-parallel laminae, and cross-cutting veinlets (**Bateson, 1990**). The primary pyrrhotite is replaced by pyrite in zones of gold mineralization, and **Bateson (1990)** suggests that sulfidation of pyrrhotite may have facilitated gold deposition. Mineralization at the Jones-Keystone deposit appears to be preferentially developed in volcaniclastic units and is more weakly developed in mafic flows and siltstone-shale intervals (**Lucas, 2013**).

Pyrite is the dominant sulfide present and probably forms by sulfidation of existing sulfide, oxide, carbonate, and silicate iron-bearing minerals. Pyrite is typically present at around 3-5 vol%, locally up to 10 vol%, as fine-grained disseminated irregular or euhedral grains, as usually cleavage-parallel sulfide veinlets or stringers, and in similarly oriented quartz veinlets and stringers. Subordinate pyrrhotite is present in a number of deposits and in some cases represents a pre-existing sulfide phase that was sulfidized to pyrite during Au mineralization (**Bateson, 1990**). Arsenopyrite is a significant accessory sulfide at the three largest occurrences; the Sawyer (MRDS record #10026505), the Jones-Keystone (**Lucas, 2013**), and the Lofflin mines (**Bateson, 1990**, **Lucas, 2013**), and the As content of the ores ranges from hundreds to tens of thousands of ppm geochemically.

Minor to trace sphalerite and galena are present in several deposits, but not economically significant. Chalcopyrite is present in a few deposits, and geochemically anomalous Cu in others at levels of hundreds of ppm. Analyses of high-grade ore samples from the Lofflin Mine suggest that Sb and Tl may be geochemically anomalous at levels of tens of ppm, often in association with anomalous Pb values (**Bateson, 1990**).

The dominant major and ore element hydrothermal assemblage for the gold deposits of the Sawyer-Keystone Trend is K + S + Ag ± Ag + As with minor to trace Zn ± Pb ± Sb ± Tl. Potassic enrichment is expressed as sericite in the phyllic alteration assemblage. This accompanies deposit-scale enrichment of Al_2O_3 and SiO_2 and strong depletion of Ca, Na, and Mg; probably as a result of hydrothermal mobilization, volume loss, and pressure solution. Intense alteration locally results in strong enrichment in SiO_2, as pervasive silicification or as swarms or stockworks of quartz veinlets. Pervasive sulfidation of protolith Fe content and the formation of pyrite possibly provide a catalyst and platform for the deposition of Au, Ag, As, base metals, and trace elements from hydrothermal solutions. It is possible that some of the base metals present in these deposits may be inherited from the host protoliths.

Constraints on local structure and the timing of gold mineralization

The *en echelon* deformation zones that host gold mineralization along the Sawyer-Keystone Trend appear to overprint the regional-scale first-order folds (**Figure 1**) formed by oblique reverse-sinistral transpression during the early phases of the Cherokee Orogeny (**Hibbard *et al.*, 2012**). These large, complex folds include (NW to SE) the Silver Valley Synclinorium, the Denton Anticlinorium, the New London Synclinorium, and the Denton Anticlinorium (**Stromquist and Sundelius, 1969**).

These folds may have initially been upright and symmetrical with axes oriented around 047°, but have been appressed, overturned to the southeast, and portions of some variably transposed and dismembered by formation of the Gold Hill Fault Zone in the later phases of the Cherokee Orogeny (**Hibbard *et al.*, 2012**). The Gold Hill Fault Zone (GHFZ) is a 120 kilometers long oblique-reverse fault duplex that strikes 030° and dips steeply northwest. The Gold Hill Fault forms the roof of the duplex, and is a fundamental structural boundary with an estimated stratigraphic offset of 12 kilometers (**Hibbard *et al.*, 2012**). The Silver Hill fault forms the duplex floor. It has significantly less displacement (hundreds of meters), separates domains of differing deformation style within the same group of rocks (**Hibbard *et al.*, 2012**), and may be largely brittle in character (**Standard, 2003**). Ductile-brittle deformation within the Gold Hill Fault Zone is heterogeneous, generally increasing towards the northwest, with numerous lower-order fault strands, shear zones, and meso-scale asymmetric folds.

The amplitude and tightness of the regional first-order folds increase from southeast to northwest with proximity to the Gold Hill Fault Zone. Within 5 kilometers of the fault zone, the folds are strongly appressed and the axes oriented around 030°, parallel to the Gold Hill and Silver Hill faults (**Figure 1**). About 10 kilometers to the southeast of the GHFZ, the folds are asymmetric and the axes overturned to the southeast, but the folds are more open and the axes strike about 045°-050°. About 5 kilometers southwest of the GHFZ, the axis of the Denton Anticlinorium veers abruptly from 030°-035° to a strike of about 065° and the fold becomes more open and symmetric with loss of amplitude to the northeast (**Figure 1**).

West of Asheboro, **Stormquist and Henderson (1985)** and **Seiders (1981)** mapped a complex second-order synclinorium with a series of *en echelon* axes that strike 065°-070° across the Albemarle Group from south of the Lofflin Mine into the Uwharrie Formation north of Asheboro (**Figure 2**). This synclinorium appears to be upright and symmetrical, and associated with a series of lower-order, possibly parasitic anticlines and synclines (see **Seiders, 1981**) with similar trends.

Although detailed geologic mapping is not available along much of the Sawyer-Keystone Trend, the geologic maps of **Stormquist and Henderson (1985)** and **Seiders (1981)** suggest that the gold deposits may lie along a second-order antiform similar in scale and paired with the second-order synform discussed above (**Figure 8**). Like the synform to the south, the axis of the proposed antiform may be characterized by a series of *en echelon* axial segments. The Sawyer-Keystone Trend may be axial to this antiform and the *en echelon* character of the meso-scale fold and shear zone segments hosting gold mineralization an inheritance of this geometry. Formation of these mineralized structures may be related to oblique reverse strain and localized shear along or parallel to the antiform axis.

Structures at this orientation are atypical of the Carolina Terrane in central North Carolina, and suggest relatively localized tectonic conditions, possibly due to buttressing of Albemarle Group deformation against the older, possibly more rigid Hyco Arc sequence to the north. This ENE-trending folding appears to post-date formation of the NE-trending first-order folds in the Albemarle Sequence and may have occurred during the later phases of the Cherokee Orogeny in the early Silurian (**Hibbard *et al.*, 2012**), possibly synchronous with large-scale reverse strain on the Gold Hill Fault Zone.

Comparison with gold deposits of similar age and genesis in the Carolina Terrane

Formation of mesozonal orogenic quartz vein and silicic alteration zone lode gold mineralization (Gold Hill-type) was widespread along the first-order Gold Hill Fault Zone during the Cherokee Orogeny (**Hibbard *et al.*, 2012**). This deposit type is well represented by the Randolph, Barnhardt, and Isenhour-Whitney gold deposits in the Gold Hill District of Rowan and Cabarrus counties (**Pardee and Park, 1948**; **Moye, 2016**) and the Stewart Mine group, Lewis Mine Group, and Howie Mine in Union County (**Pardee and Park, 1948**; **LaPoint and Moye, 2013**). These deposits are classified as USGS ore deposit model 36a, *Low-sulfide Au-quartz vein* (URL https://pubs.usgs.gov/of/1995/ofr-95-0831/CHAP34.pdf, viewed 01 January 2018) and consistent with *lode gold deposits* of the *2.7 Orogenic mineral system classification* of Geoscience Australia (http://www.ga.gov.au/data-pubs/data-and-publications-search/publications/critical-commodities-for-a-high-tech-world/orogenic-mineral-systems, viewed 01 January 2018).

The mineralization is synkinematic and synmetamorphic, developed along low-order reverse or oblique shear zones and fault strands, and concentrated in narrow zones of intense silicic alteration, sheeted quartz veins, and veinlet stockworks with typically ≤ 5 vol% sulfides, chiefly pyrite, locally with minor accessory chalcopyrite, galena, sphalerite, and, rarely, arsenopyrite in some deposits (**Pardee and Park, 1948**; **LaPoint and Moye, 2013**; **Moye, 2016**). Phyllic alteration is variably developed over narrow intervals on the hanging wall and foot wall of the lodes and carbonate is a common gangue accessory.

The Randolph and Barnhardt Mines together produced an estimated 115,000 ounces of gold, representing 72% of total production from the Gold Hill District (**Pardee and Park, 1948**). The lodes typically pinch and swell from 15 to 120 centimeters thick over a strike length seldom exceeding 500 meters, with ore-grade mineralization commonly confined to steeply plunging shoots (**Laney, 1910**; **Pardee and Park, 1948**). The Randolph lode reached a maximum of 2.0 meters thick (**Pardee and Park, 1948**) and the Barnhardt lode was locally up to 3.7 meters thick (**Laney, 1919**).

Gold Hill-type orogenic gold deposits are typically located along narrow, well-defined zones of high ductile-brittle strain and formed by repeated crack-seal mineralizing events. These structures may be continuous over kilometers or *en echelon* in segments hundreds of meters long. Although lodes are typically narrow, multiple parallel mineralized structures may be present over widths of 100-200 meters (**Pardee and Park, 1948**; **Moye, 2016**). In the central Gold Hill District at a depth of 245 meters, a total of 11 mineralized structures are present over an across-strike width of about 200 meters, and include the North, Randolph, and Miller (Barnhardt) veins (**Laney, 1910**). Only portions of the three major veins could be mined profitably in primary sulfide ore but none of the eight narrow, discontinuous structures were economic (**Laney, 1910**).

However, relatively low Au-grade veins may have yielded easily recovered, payable gold at the surface and in the oxidized zone of supergene weathering. Broad zones of multiple narrow mineralized structures may have yielded payable placer or residual surface gold accumulations. Many Gold Hill-type orogenic gold deposits along the Gold Hill Fault Zone were only mined to the water table at depths of 30-40 meters (**Laney, 1910**; **Pardee and Park, 1948**).

The character of Gold Hill-type orogenic lodes contrasts sharply with that of the major gold deposits of the Sawyer-Keystone Trend (Sawyer-type), although both groups appear to have formed during the same orogenic event. Significant distinctions involve the volume and character of host rock alteration, the nature of the structural controls, and possibly the amount of brittle-ductile strain involved. Similarities in major and minor metallic element budgets, trace elements, and alteration mineral assemblages suggest formation by hydrothermal fluids of similar chemistry and origin. However, geochemically significant arsenic, typically as accessory arsenopyrite, is characteristic of Sawyer-type gold deposits but generally rare in Gold Hill-type deposits, possibly suggesting some divergence in ore fluid composition. Additionally, the two deposit types contrast in the susceptibility of the alteration assemblages to intense supergene oxidation and acid leaching.

Both types of gold deposits may occur as multiple parallel, sometimes *en echelon* mineralized structures. Oxidation and weathering of lower Au-grade major structures and narrow, more strongly mineralized structures in both types may have produced wide zones of economically minable free-milling gold at and near the surface. Some Gold Hill-type lode deposits contained ore shoots of sufficient grade and tonnage in primary sulfide mineralization to justify subsurface historical mining (**Laney, 1910**; **Pardee and Park, 1948**). Subsurface mining of primary sulfide ore in Sawyer-type deposits does not appear to have been historically economic, but most drill-hole evaluation of these deposits has been to relatively shallow levels, often less than 100 meters.

Spatial distribution of Sawyer-type deposits

All of the larger gold deposits along the Sawyer-Keystone Trend appear to be Sawyer-type Au-Ag-As mineralization. Although some of the smaller, less well described deposits are of an uncertain character, none appear to be classic Gold Hill-type orogenic lode gold mineralization. All of the known orogenic lode gold deposits within the Gold Hill Fault Zone appear to be of the classic Gold Hill-type, although there is a range of variations associated with local structural controls and host rock characteristics. This distribution suggests a possible spatial separation in gold deposit types formed during the Cherokee Orogeny in the late Ordovician to early Silurian (**Hibbard *et al.*, 2012**), possibly related to differences in host rocks, fluid chemistry and host rock interactions, structural controls, or depth of emplacement.

However, both Gold Hill-type and Sawyer-type gold deposits occur in the Ophir District in northern Montgomery and southern Randolph counties, North Carolina. Gold Hill-type lodes include the Steel, Griffin, Stafford, and Eldorado mines. Sawyer-type lodes include the Russell, Coggins, and possibly the Riggon Hill mines. All are hosted by thin-bedded turbidite mudstone-siltstone units of the Tillery Formation, all appear to be of the same general age, and all are syntectonic and appear to have formed under similar P-T conditions. The compelling difference between Sawyer-type and Gold Hill-type orogenic gold deposits in the Ophir District is the divergence of structural controls. Gold Hill-type deposits are hosted by generally narrow, individual ductile-brittle fault structures. However, the Sawyer-type deposits are hosted by broad zones of intense cleavage development associated with discontinuous zones of asymmetric, appressed meso-scale folds and reverse faulting (**Klein *et al.*, 2007**). The structural controls of both deposit types represent localized, intermittently tensional domains within a dominantly compressive orogenic framework. The only major distinction is in deposit morphology, the character of meso- to micro-scale structural pathways, and the volume of the domain of fluid-rock interaction.

Conclusions

Development of structurally hosted gold deposits along the Sawyer-Keystone Trend in northwest Randolph County, North Carolina was synkinematic and synmetamorphic with the later phases of deformation associated with the Cherokee Orogeny in the late Ordovician to early Silurian (**Hibbard *et al.*, 2012**). The major deposits, including the Sawyer and Jones-Keystone mines, are characterized as multiple parallel zones tens to hundreds of meters wide of cleavage-parallel phyllic to silicic alteration. Mineralization is low total sulfide (3-5% vol %), pyrite-dominant (± pyrrhotite ± arsenopyrite ± base metal sulfides), as disseminated grains, sulfide stringers, and in cleavage-parallel quartz veinlets and stringers. Higher Au grades are typically associated with zones of intense silicic alteration up to 10 meters thick.

The structural controls of Sawyer-type deposits appear to be zones of probable reverse-oblique ductile-brittle strain typically hundreds of meters wide, characterized by meso-scale asymmetric folds overprinted by zones of intense axial cleavage development that are typically tens of meters wide. The well-spaced, *en echelon* distribution of mineralized deformation zones along the Sawyer-Keystone Trend and the absence of a through-going major fault suggests relatively low total strain.

The distinctive character of the Sawyer-type orogenic gold deposits of the Carolina Terrane in North Carolina may be due largely to the development of broad zones of intense penetrative cleavage. This cleavage provided pathways for hydrothermal fluids and served to distribute heterogeneous fluid flow through a large volume of the host lithology, maximizing fluid-rock interaction and resulting in pervasive sulfidation and the dominance of phyllic alteration over silicic alteration. Pyrite formation may be an important mechanism in gold deposition, and much of the gold budget in primary sulfide ore may be contained in pyrite, either as stoichiometric content or microscopic inclusions.

Within zones of strong cleavage and phyllic alteration, brittle failure and reverse or oblique displacement sub-parallel to cleavage may form broad zones of minor reverse faults that provided higher volume fluid pathways, distinguished by more intense silicic alteration and higher-grade gold mineralization. This dominance of large volumes of auriferous phyllic alteration over subordinate silicic alteration in Sawyer-type gold deposits contrasts strongly with the dominance of silicic alteration in Gold Hill-type orogenic gold deposits. Additionally, strongly foliated pyritic phyllic and silicic alteration are highly susceptible to supergene oxidation and weathering enhanced by acid leaching to the depth of the local water table, forming large volumes of generally low-grade but easily mined and free-milling gold ore.

The development of Sawyer-type gold deposits appears to be more dependent on host rock composition and texture than the formation of Gold Hill-type deposits, which may be more influenced by host rock rheology. Preferred host rocks are suggested for the Lofflin Mine (**Bateson, 1990**; **Lucas, 2013**) and the Jones-Keystone Mine (**Lucas, 2013**), however little information is available on the chemical composition, texture, and rheology of these hosts. The presence of sufficient iron in forms amenable, through sulfidation, to form pyrite and facilitate gold deposition may be an important factor, along with a rock texture and composition that supports development of a strong penetrative cleavage.

The significance of geochemically highly anomalous arsenic in many Sawyer-type deposits, often as accessory arsenopyrite, contrasts strongly with most Gold Hill-type orogenic gold deposits along the Gold Hill Fault Zone, but the significance is unclear. **Groves *et al.* (1998)** suggest that accessory arsenopyrite is more common in orogenic gold deposits hosted by metasedimentary rocks. Metamorphosed siltstone-mudstone turbidites dominate the stratigraphy of the Mudstone Member of the Cid Formation and the Tillery Formation (**Stromquist and Sundelius, 1969**). Both host Sawyer-type deposits of the Sawyer-Keystone trend in Randolph County and in the Ophir District in Montgomery County; however, these formations also host many Gold Hill-type deposits within the Gold Hill Fault Zone.

The spatial association and metallogenic similarity of both Gold Hill-type and Sawyer-type orogenic gold deposits in the Ophir District of Montgomery County, North Carolina suggests that both deposit types formed under similar P-T conditions at a similar time during the later phases of the Cherokee Orogeny (**Hibbard *et al.*, 2012**). Both deposit types appear to be part of the broad family of orogenic gold deposits (**Groves *et al.*, 1998**; **Geoscience Australia,** http://www.ga.gov.au/data-pubs/data-and-publications-search/publications/critical-commodities-for-a-high-tech-world/orogenic-mineral-systems, viewed 01 January 2018). The absence of features indicative of formation at shallow crustal depths suggests that both Sawyer-type and Gold Hill-type orogenic gold deposits can be classified within the mesozonal subtype of orogenic gold deposits proposed by **Groves *et al.* (1998)**, formed at depths of 6-12 kilometers and at temperatures of 300°-475°C. The Sawyer-type and Gold Hill-type deposits of the Carolina Terrane probably formed at the lower P-T end of this range under lower greenschist facies metamorphic conditions.

Speculations on economic potential

The shear zone hosted Au-Ag-As deposits of the Sawyer-Keystone Trend and the Ophir District represent a distinct style of orogenic gold deposit formed during the Cherokee Orogeny (**Hibbard *et al.*, 2012**) in the Carolina Terrane of central North Carolina. They are typically of lower average Au-grade compared to typical orogenic gold lode deposits (Gold Hill-type), but often with 1-2 orders of magnitude higher tonnage. However, the total recoverable gold resource associated with these deposits is poorly constrained.

The largest of the Gold Hill-type orogenic gold deposits in the Carolina Terrane in North Carolina individually produced 20,000 to around 90,000 ounces of gold, and the Randolph and

Barnhardt Mines of the Gold Hill District together produced an estimated 115,000 ounces (**Pardee and Park, 1948**). Although documented gold production for the individual deposits of the Sawyer-Keystone Trend is typically minor (<10,000 ounces Au), their total formal + informal mined gold output is undocumented.

Total documented historical gold production for the Russell Mine, a Sawyer-type deposit in the Ophir District, is around 15,000 ounces troy between about 1882 and 1894 (**Nitze and Hanna, 1896**, **Pardee and Park, 1948**; **Klein *et al.*, 2007**). However, **Maddry *et al.* (1992)** estimate total past formal + informal production as high as 37,500 ounces (1166 kg) Au, much of it poorly documented. Based on modern drilling and sampling of the Russell Mine deposit, **Maddry *et al.* (1992)** published a remaining proven plus probable minable resource of 4 Mt of ore at an average grade of 1.6 g/t (0.047 oz/t) gold and containing 209,380 ounces Au (6.5 metric tonnes), along with an additional possible resource of 3.2 Mt at 1.2 g/t (0.035 oz/t) Au, for a total of 331,100 ounces (10.3 metric tonnes) of gold. This would suggest a possible mined + remaining resource of over 350,000 ounces Au for the Russell Mine deposit.

The total gold resource for some Sawyer-type deposits in the Sawyer-Keystone Trend may be similar to that of the Russell Mine. Additionally, pervasive oxidation, acid leaching, and weathering to a depth of 20-40 meters results in large volumes of easily disaggregated, free-milling ore that is amenable to low-cost bulk mining, processing, and gold recovery. Sawyer-type mesozonal orogenic gold deposits are among the most prospective and potentially economic targets for precious metal exploration in the Carolina Terrane in North Carolina.

References cited

Bateson, J.T., 1990, Summary report of the Lofflin Project: August 1989 through July 1990, volume 1: Unpublished report, Noranda Exploration Inc., 28p.

Berger, B.R., 1985, Geologic-geochemical features of hot-spring precious metal deposits: *in*, Tooker, E.W. (editor), Geologic characteristics of sediment- and volcanic-hosted disseminated gold deposits-Search for an occurrence model: U.S. Geological Survey, Bulletin 1646, p. 47-54.

Bryson, H. J., 1936, Gold deposits in North Carolina: North Carolina Geological Survey, Bulletin 38, 162p.

Carpenter, P. A. III, 1976, Metallic mineral deposits of the Carolina Slate Belt, North Carolina: North Carolina Department of Natural and Economic Resources, Bulletin 84, 165p.

Emmons, E., 1856, Geological report of the Midland Counties of North Carolina: North Carolina Geological Survey, 347p.

Groves, D.I.; Goldfarb, R.J.; Gebre-Mariam, M.; Hagemann, S.G., and Robert, F., 1998, Orogenic gold deposits: A proposed classification in the context of their crustal distribution and relationship to other gold deposit types: Ore Deposit Reviews, 13, p. 7-27.

Hibbard, J.; Miller, B.; Hames, W.; Standard, I.; Allen, J., Lavallee, S., and Boland, I., 2012, Kinematics, U-Pb geochronology, and $^{40}Ar/^{39}Ar$ thermochronology of the Gold Hill shear zone, North Carolina: The Cherokee orogeny in Carolinia, Southern Appalachians: Geological Society of America, Bulletin, v. 124, no. 5/6; p. 643-656.

Kerr, W. C., and Hanna, G. B., 1888, Ores of North Carolina: Geology of North Carolina, v. 2, chap. 2, p. 123-359.

Kinkel, A. R., Jr., 1974, Geochemical sampling at the Jones-Keystone Mine, Randolph County, North Carolina: U.S. Geological Survey, Open-File Report 74-1058, 5p.

Klein, T.L., Cunningham, C.G., Logan, M.A.V., and Seal, R.R., II, 2007, The Russell gold deposit,

Carolina Slate Belt, North Carolina: Economic Geology, v. 102, p. 239–256.
Laney, F. B., 1910, The Gold Hill mining district of North Carolina: North Carolina Geological and Economic Survey, Bulletin 21, 137p.
LaPoint, D.J. and Moye, R.J., 2013, Gold and base metal mineralization in the Carolina terrane of central North Carolina: *in*, Hibbard, J.P. and Pollock, J., (editors) One arc, two arcs, old arc, new arc: The Carolina Terrane in central North Carolina: Carolina Geological Society Guidebook, p. 91-124.
Lucas, K., 2013, NI 43-101 Technical report on the Champion Hills Gold Project, Randolph and Davidson Counties, North Carolina: Revolution Resources Corporation, Vancouver, BC, Canada, 69p.
Luttrell, G.W., 1978, Gold, base-metal, and related deposits of North Carolina: US Geological Survey, Open-File Report 78-152, 551p.
Maddry, J.; Hart, W., and Dail, C., 1992, Exploration summary, Russell Project, Montgomery and Randolph counties, North Carolina: Unpublished report for Piedmont Mining Company Incorporated, Charlotte, NC, 23p.
Moye, R.J., 2016, Metallogenesis of the central Gold Hill District of the Carolina Terrane, Rowan and Cabarrus Counties, North Carolina: *in*, Moye, R.J., Reid, J.C., and Lee, D.F., Volcanogenic polymetallic massive sulfide deposits (VMS) of the Carolina Terrane in central North Carolina: New perspectives and historical reports and data from the files of Phelps Dodge Exploration East (1975-1982): North Carolina Geological Survey, Special Publication 11, 456p.
Nitze, H. B. C., and Hanna, G. B., 1896, Gold deposits of North Carolina: North Carolina Geological Survey, Bulletin 3, 200p.
Nitze, H. B. C., and Wilkens, H. A. J., 1897, Gold mining in North Carolina: North Carolina Geological Survey, Bulletin 10, 164p.
Pardee, J. T., and Park, C. F., Jr., 1948, Gold deposits of the southern Piedmont: U.S. Geological Survey, Professional Paper 213, 156p.
Pratt, J. H., 1904, The mining industry in North Carolina during 1903: North Carolina Geological Survey, Economic Paper 8, 74p.
Pratt, J. H., 1907, The mining industry in North Carolina during 1906: North Carolina Geological and Economic Survey, Economic Paper 14, 144p.
Pratt, J.H. and Berry, H.M., 1919, The Mining Industry in North Carolina during 1913-17, inclusive: North Carolina Geological Survey, Economic Paper No. 49, 162 p.
Seiders, V., 1981, Geologic map of the Asheboro Quadrangle, North Carolina, and adjacent areas: U.S. Geological Survey, Miscellaneous Investigations Map I-1314, scale 1:62,500.
Standard, I., 2003, Kinematics and timing of the Gold Hill fault zone in the vicinity of High Rock Lake, south-central North Carolina: Unpublished MS thesis, North Carolina State University, Raleigh, NC, 102p.
Stromquist, A.A.; Choquette, P.W., and Sundelius, H.W., 1971, Geologic map of the Denton Quadrangle, central North Carolina: U.S. Geological Survey, Map GQ872, scale 1:62,500.
Stromquist, A., and Henderson, J., 1985, Geologic and geophysical maps of south-central North Carolina: U.S. Geological Survey, Miscellaneous Investigations Series Map I-1400, scale 1:62,500.
Stromquist, A., and Sundelius, H., 1969, Stratigraphy of the Albemarle Group of the Carolina Slate Belt in central North Carolina: US Geological Survey, Bulletin 1274-B, 22p.

Figure 1. Location of Sawyer-Keystone area in the Carolina Terrane in central North Carolina (see **Figure 2**).

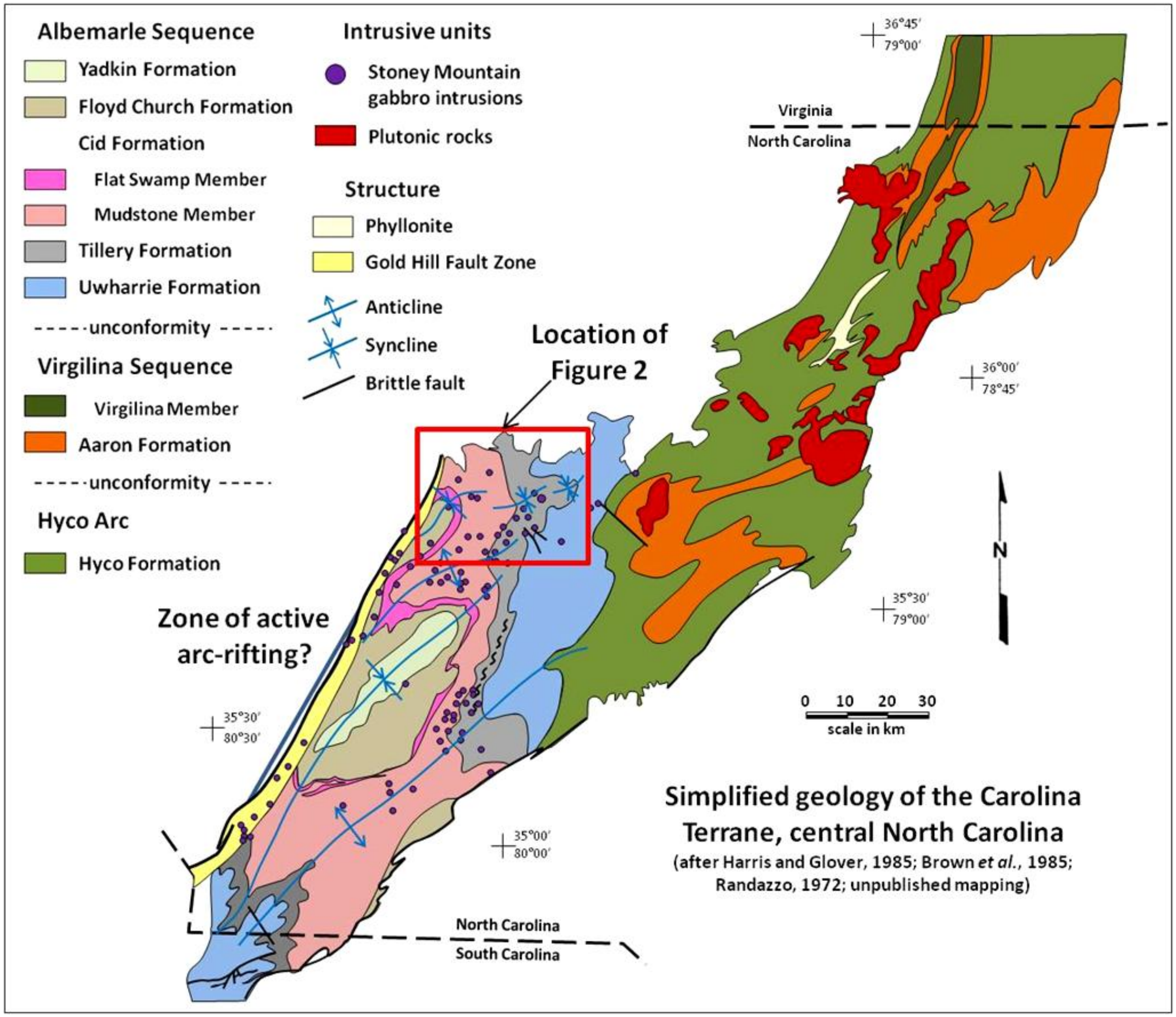

Figure 2. Simplified geology and location of mines and prospects of the Sawyer-Keystone Trend in northwest Randolph County, North Carolina. The trend cuts across the axes of first-order regional folds formed in the early stages of the late Ordovician-early Silurian Cherokee Orogeny, and may be associated with a late phase of smaller scale folding and faulting oriented about 065°.

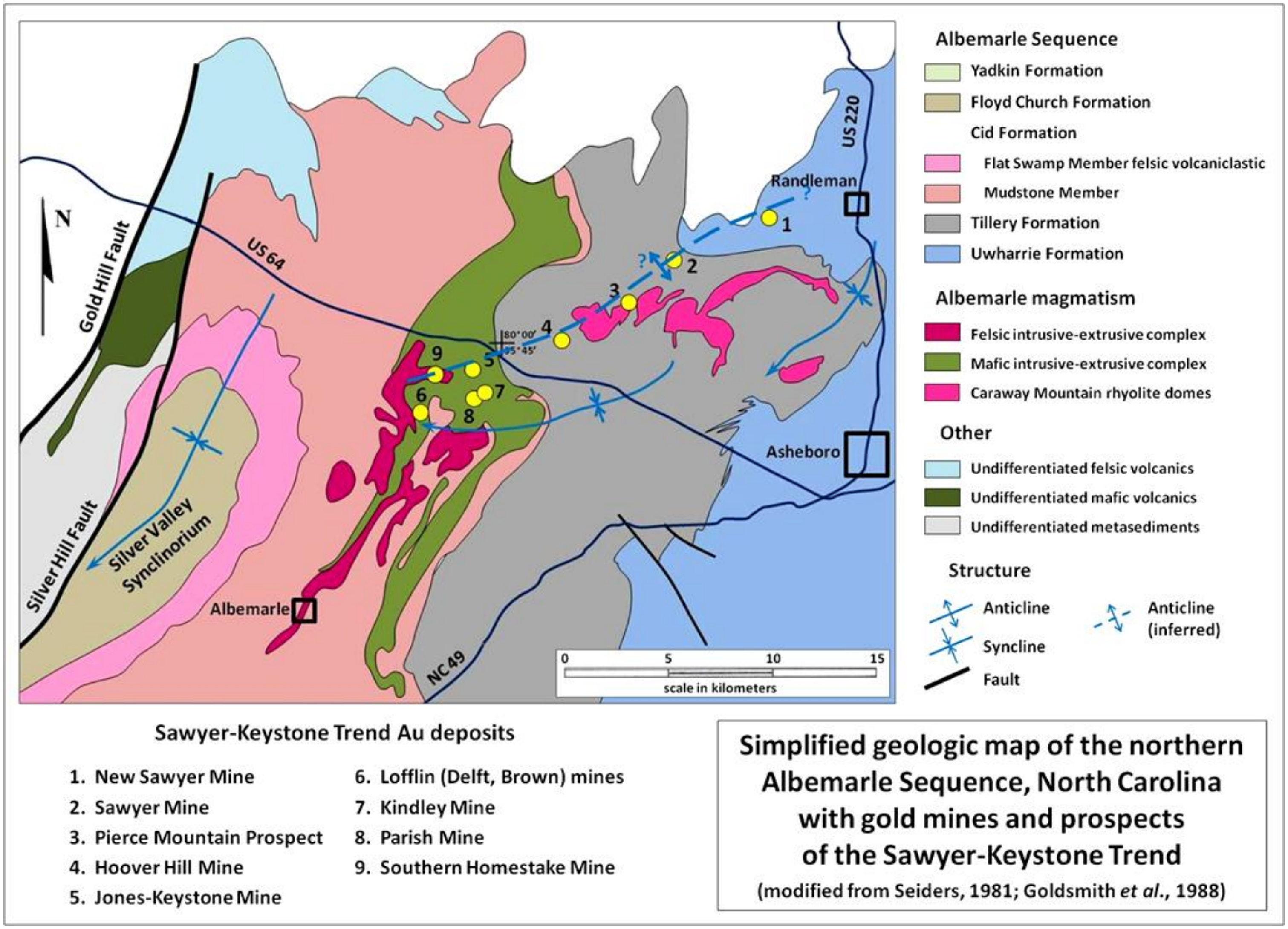

Figure 3. Principle mineralized zones of the Sawyer Gold Mine (modified from **Pratt, 1907**).

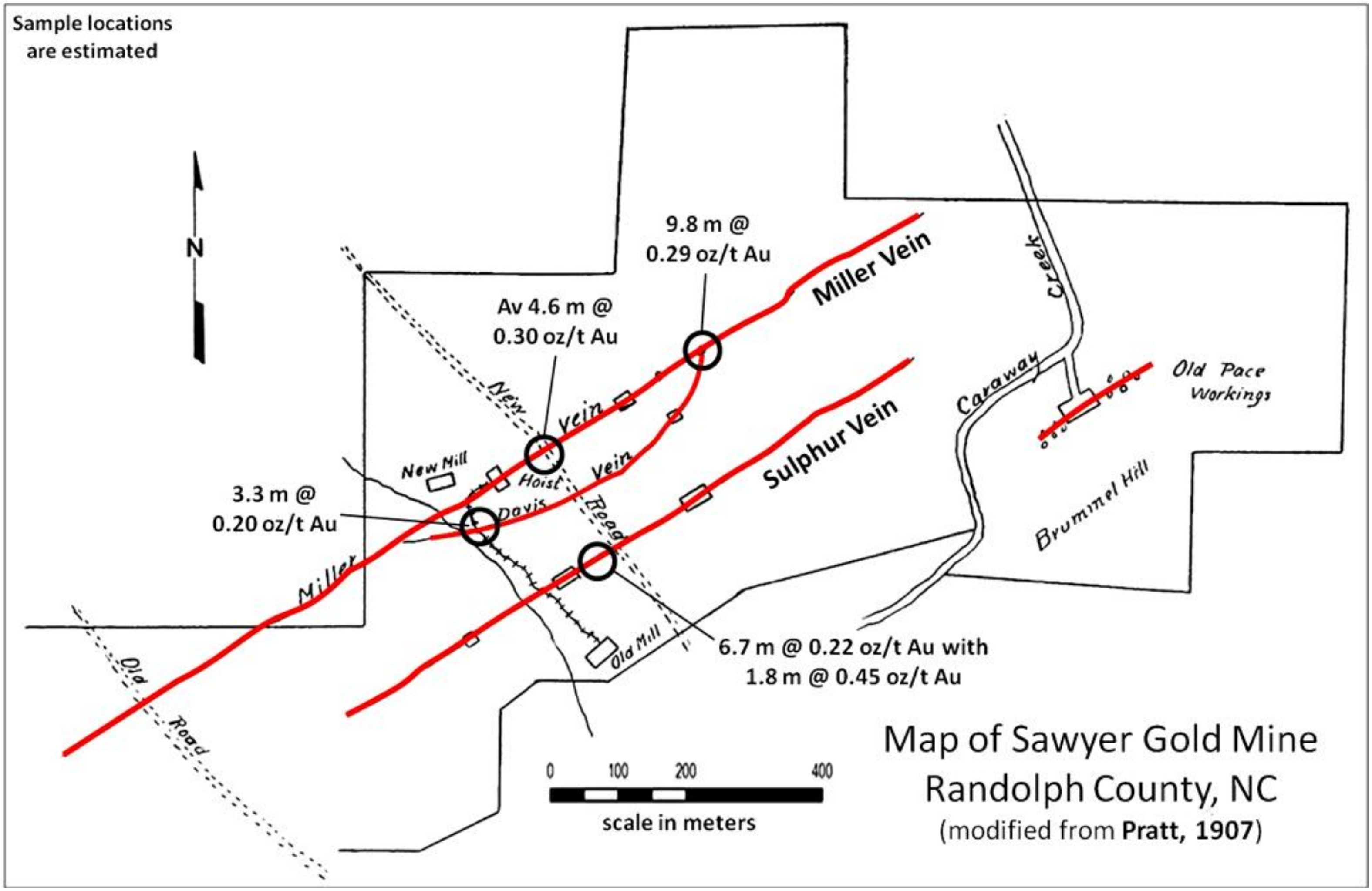

Figure 4. Major historical open cut workings of the Jones-Keystone Au Mine (modified from **Pardee and Park, 1948**).

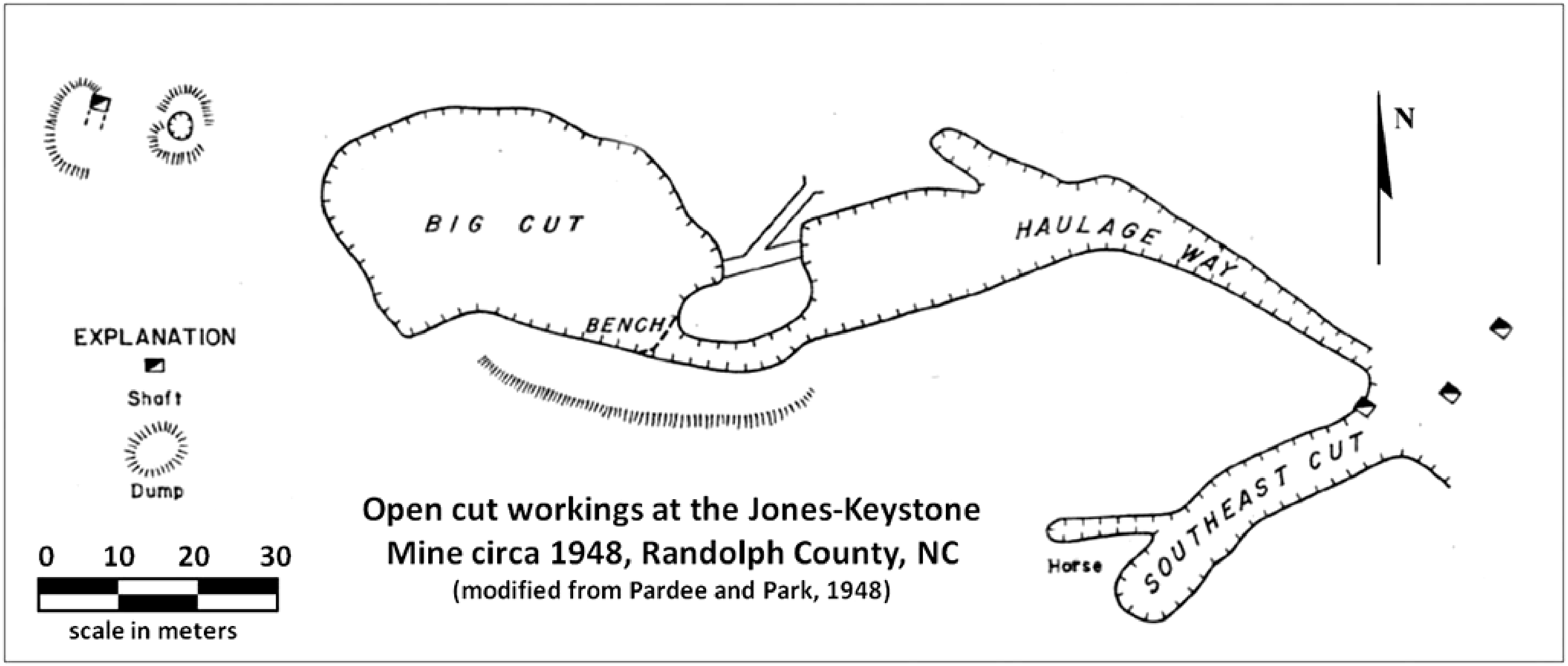

Figure 5. Geologic map of the Jones-Keystone Au Mine with major mineralized zones (modified from **Lucas, 2013**).

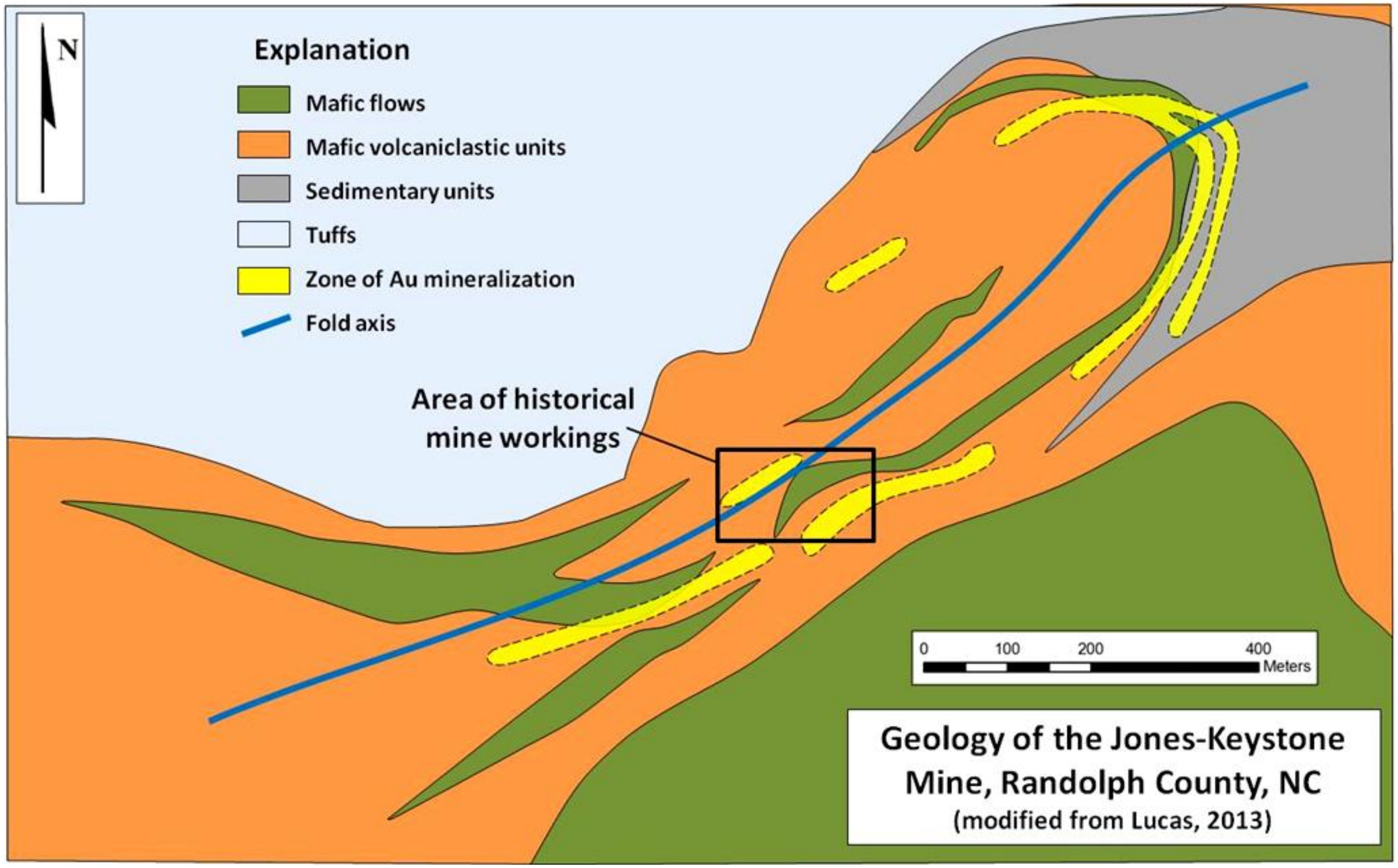

Figure 6. Drill-hole cross-section through the Jones-Keystone Au deposit showing mineralized intervals (modified from **Lucas, 2013**).

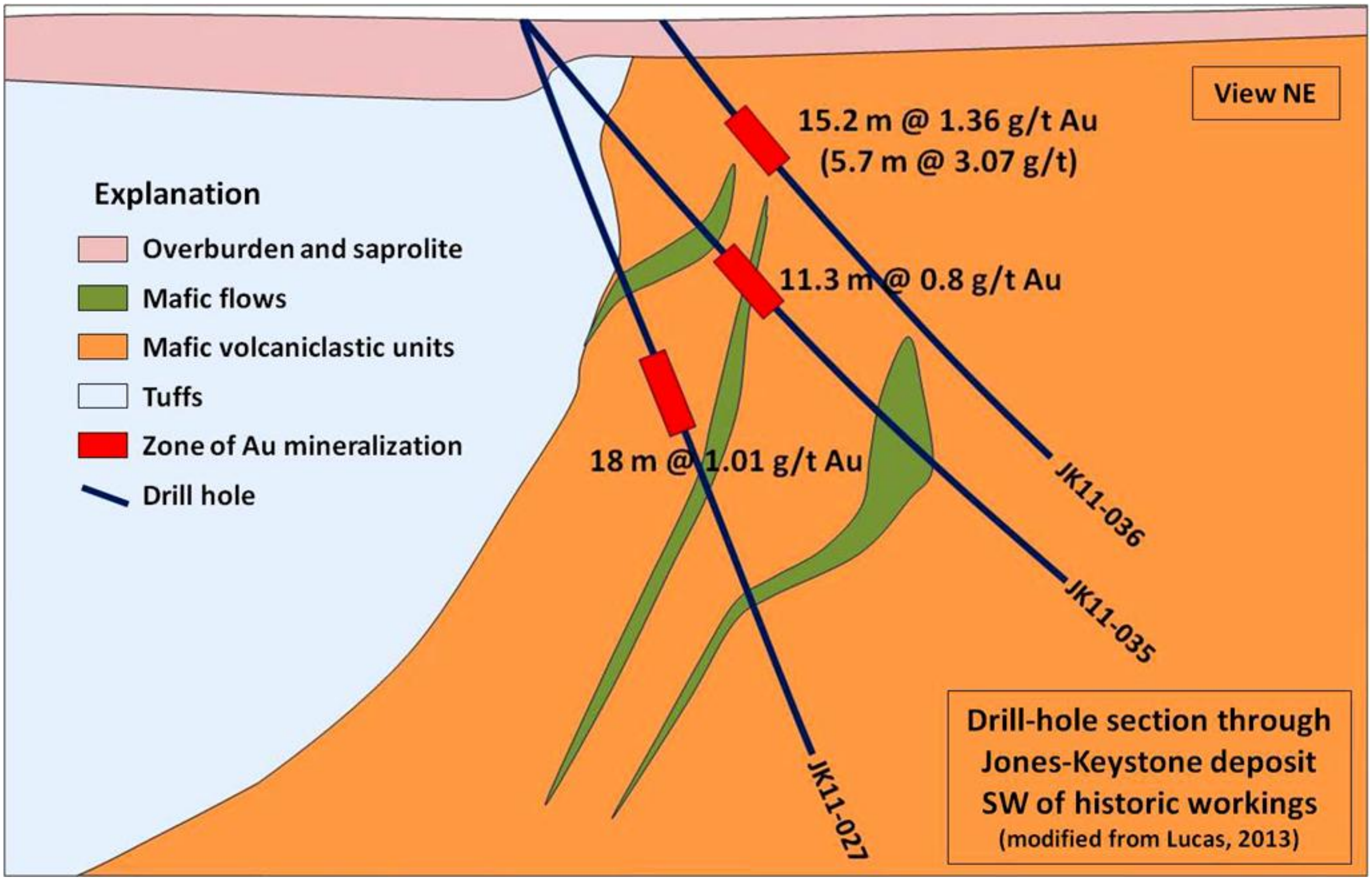

Figure 7. Gold distribution in historical Jones-Keystone Mine workings (modified from **Kinkel, 1974**).

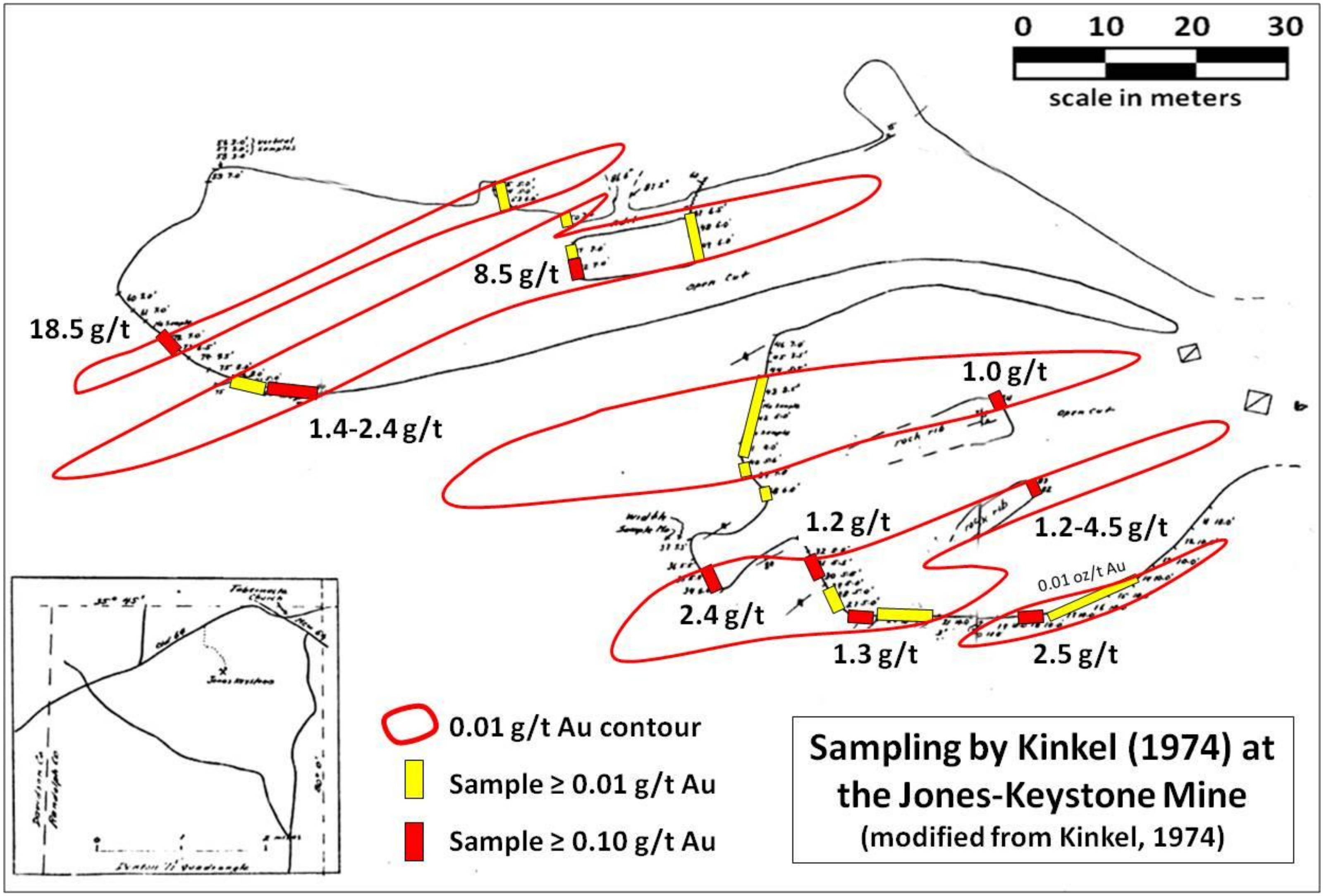

Figure 8. Geology and gold mineralization in the Lofflin Mine area (modified from **Bateson, 1990**).

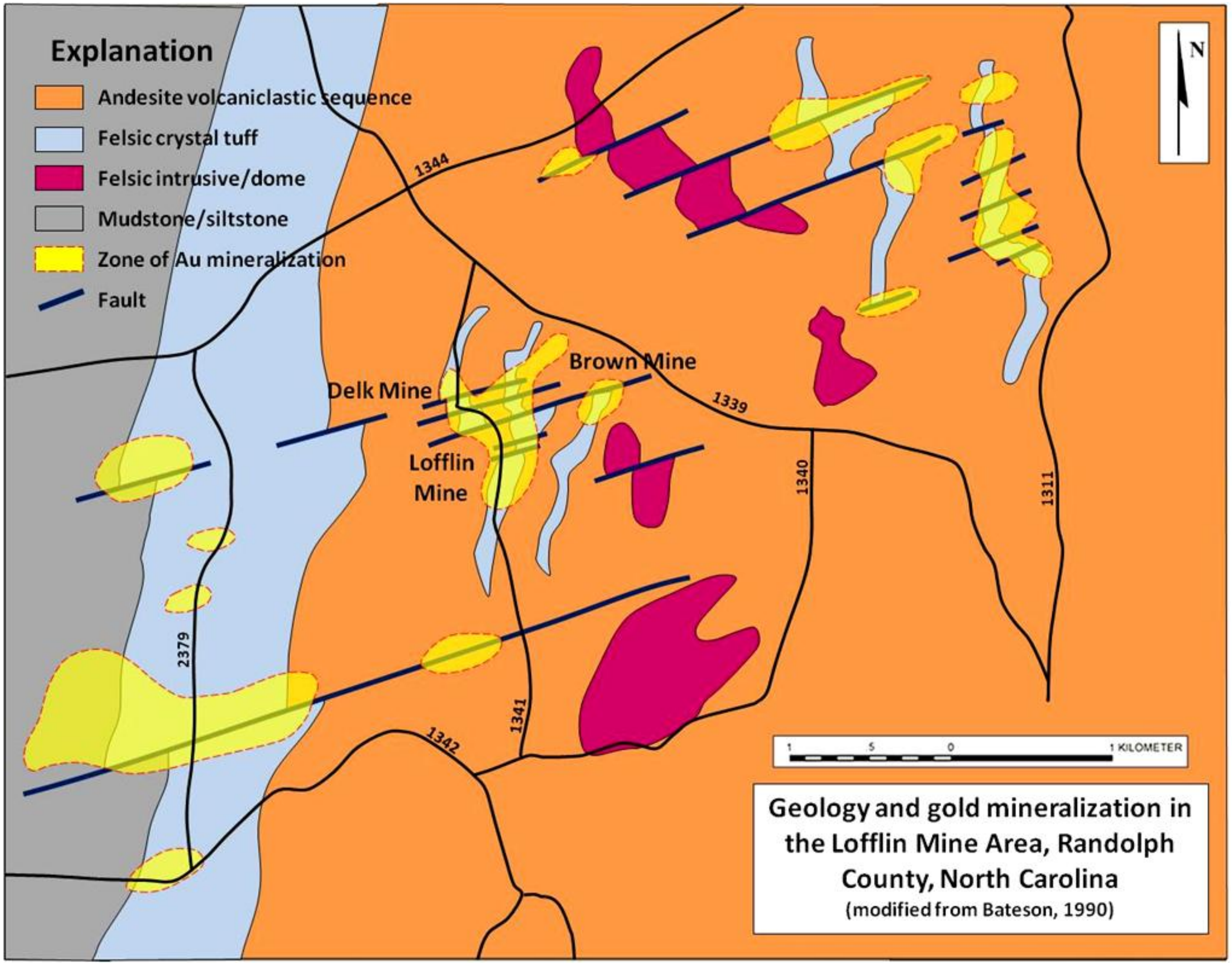

Figure 9. Possible antiform axial to the Sawyer-Keystone Trend (modified from **Seiders, 1981** and **Goldsmith *et al.*, 1998**). The discontinuous shear zones hosting gold mineralization may be part of a low-strain axial fault zone.