Bergvesenet
Postboks 3021, N-7441 Trondheim

Rapportarkivet

Bergvesenet rapport nr	Intern Journal nr	Internt arkiv nr	Rapport lokalisering	Gradering
4669				**Åpen**

Kommer fra ..arkiv	Ekstern rapport nr	Oversendt fra	Fortrolig pga	Fortrolig fra dato:
Folldal Verk AS		Tverrfjellet		

Tittel
Forslag til videre undersøkelser mhp. gull i Rombakvinduet, Nordland

Forfatter	Dato År	Bedrift (Oppdragsgiver og/eller oppdragstaker)
Tollefsrud, Jan Inge Korneliussen, Are	1986	Folldal Verk AS NGU

Kommune	Fylke	Bergdistrikt	1: 50 000 kartblad	1: 250 000 kartblad
Narvik	Nordland		13163	Narvik

Fagområde	Dokument type	Forekomster (forekomst, gruvefelt, undersøkelsesfelt)
Geologi		Gautelisfjell

Råstoffgruppe	Rastofftype
Malm/metall	Au

Sammendrag, innholdsfortegnelse eller innholdsbeskrivelse

Notat med bakgrunnstoff om gullforekomst av Carlin-type

NGU 20/10-86.

FORSLAG TIL VIDERE UNDERSØKELSER M.H.P. GULL I ROMBAKVINDUET, NORDLAND.

Bakgrunn: Rombaken grunnfjellsvindu har i perioden 1983-1985 vært gjenstand for omfattende malmundersøkelser av ARCO Norway, Folldal verk A/S og NGU. Tilsammen er det investert ca. 10 mill. kr i disse undersøkelser som har skaffet til veie et interessant geologisk bakgrunnsmateriale. Utgangspunktet er usedvanlg gunstig for - gjennom videre undersøkelser, å påvise økonomisk interessante gullforekomster.

NGU-rapport 86.193 (delrapport til EF-gullprosjekt) "Precambrian volcano-sedimentary sequences and related ore deposits, with special reference to the Gautelisfjell carbonate-hosted disseminated gold deposit, Rombaken basement window, Northern Norway" av A.Korneliussen, J.I.Tollefsrud, B.Flood og E.Sawyer, gir en oppsummering av de resultater som foreligger.

Det er helt klart at prosesser som har ført til effektiv oppkonsentrering av gull har vært aktive i vinduet. Gautelisfjell gullforekomst viser dette. Gullet i forekomsten er usynlig og assosiert med svake sulfidmineraliseringer (<2% S) disseminert i en uren kalkstein i en vulkanitt/sediment sekvens. Gull-mineraliseringene opptrer uregelmessig over 10-20 m mektighet i en uren, metamorfosert (amfibolitt-facies) og sterkt deformert kalkstein. Gullgehaltene er opptil 20 ppm lokalt. Over 3 m mektighet i borhull er det påvist gjennomsnittsgehalter på opptil 7 ppm Au. Bare deler av den mineraliserte kalken er undersøkt med borhull (totalt 1500 m er boret). Forekomsten er helt klart av økonomisk interesse. Like viktig er det at forekomsten er en ny type for Norge, og kunnskap om dannelse og opptreden vil være av overordentlig stor betydning for videre undersøkelser etter gull i Rombakvinduet såvel som i andre grunnfjellsområder i landet.

I tillegg er det påvist en rekke gull-anomalier (0.5-15 ppm Au) i bekksesedimenter og vaskekonsentrater i andre deler av vinduet. Disse anomalier er så godt som ikke fulgt opp i felt.

Hypotese som må testes:

(1) Gautelisfjell gullforekomst er av Carlin-type og er dannet fra relativt lavtemperatur løsninger som har strømmet langs skjærsoner. Gullet er utfelt i karbonat der hvor skjærsonen(e) treffer karbonathorisonten.

(2) Skjærsoner også andre steder i vinduet har virket som kanaler for hydrotermale løsninger som har gitt gullmineraliseringer der hvor disse treffer karbonathorisonter.

Følgende undersøkelser foreslås:

(1) Gautelisfjell.
- Eksisterende prøver (bl.a. borkjerner) både med og uten gull, re-analyseres på S, Bi, Te, As, grafitt m.m., for å få fram et bilde av elementkorrelasjoner og fordelingen i kalken.
- Mineralogien undersøkes i detalj gjennom mikroskopering og mikrosondeanalyser.
- Skjærsoner kartlegges og tolkes, bl.a. markerte N-S gående breksjesoner i suprakrustalene ved Gautelisvatn 2 km fra forekomstområdet.
- Relasjonene mellom granodiorittiske og granittiske intrusiver i forekomstområdet undersøkes i detalj.
- Det foretas en detaljert sammenlikning med Carlin-type forekomster ellers i verden.

(2) Skjærsoner og karbonater utenfor Gautelisområdet.
- En flyfototolkning av hele vinduet utføres m.h.p. skjærsoner.
- Dette etterfølges av detaljert oppfølging i delområder som har (a) karbonater, (b) interessante strukturer og (c) er anomale på gull i løsmasser.

Deltakere:

Jan Inge Tollefsrud, Folldal Verk A/S

Boye Flood, Geologiske Tjenester

Are Korneliussen, NGU

Utgifter:

Feltutgifter (3 mann i 8 uker):	kr 200.000,-
Lønn (3 mann i 9 nd.)	kr 700.000,-
Totalt:	kr 900.000,-

Finansiering:

NGU:

Andre:

Prosjektvarighet: April 1987 - des. 1987 (9 mnd.)

Bergrettigheter:

Resultatene behandles konfidensielt i prosjektperioden og i 1/2 år etter at avsluttende rapport foreligger.

De innvolverte selskaper må løse mutings-problemet seg imellom.

NGU/Staten vil ikke mute i området i den tid materialet behandles konfindensielt.

J.I.T/A.K.

Tollefsrud

ANG. VIDERE UNDERSØKELSER I ROMBAKVINDUET

Møte hos Geologiske Tjenester 30/10-1986.

Deltakere: B.Flood (Geologiske Tjenester), J.Heim, I.Killi og J.I.Tollefsrud (Folldal Verk) og I.Lindahl og A.Korneliussen (NGU).

Formål med møtet: Diskutere eventuelt samarbeide i 1987 m.h.p. gull i Rombakvinduet.

Et notat "Forslag til videre undersøkelser m.h.p. gull i Rombakvinduet, Nordland" av Tollefsrud/Korneliussen ble sendt til deltakerne på forhånd.

Resultater:

(1) Alle parter var interessert i et samarbeide om videre gull-undersøkelser. Problemet er hvordan dette kan la seg finansiere.

(2) Det ble inngått en avtale om å behandle ARCO's rappportmateriale konfidensielt ut 1987. Folldal Verk og NGU forpliktet seg til ikke å ta ut nye mutinger i de aktuelle områder i denne perioden.

(3) En EF-gullprosjekt rapport som er basert på materiale fra Folldal verk, ARCO og NGU, skal behandles konfidensielt til 1/4-1987.

(4) Forslaget til videre undersøkelser omarbeides. Folldal Verk og Geologiske Tjenester utarbeider hvert sitt kortfattede forslag til videre undersøkelser av Gautelisfjell gull-forekomst (Folldal Verk) og ett eller to av ARCO's gull-anomale områder (Geologiske

Tjenester). Forslagene sendes Korneliussen innen 30/11, og vil bli inkorporert i et samlet forslag.

(5) UTGIFTER. NGU v/USB-prosjektet kan med stor sannsynlighet benytte noe midler til undersøkelser i Muohtaguobla og tilgrensende områder. Omfanget vil være avhengig av den innsatsen som kan gjøres av de andre partene. NGU's budsjettfordeling vil bli endelig avgjordt 2/2-1987. Lønnsutgifter kommer i tillegg (ett årsverk).

Folldal Verk og Geologiske Tjenester får klarlagt sine budsjettrammer henholdsvis ca 1. og 15. desember i år.

Den endelige utforming av samarbeidet for 1987 foretas når alle budsjettrammer er klare, d.v.s. i februar 1987.

NGU 11/11-86

Are Korneliussen

The Next Exploration Stage for Carlin-Type Gold Deposits

Joseph G. Wargo

A meteoric rise in selling price has revived gold exploration activity throughout the world. In the United States the effort is, in large measure, channeled toward discovery of disseminated gold deposits such as the Carlin-type, i.e., with size and grade characteristics similar to Newmont's Carlin mine in Nevada.

The subtle surface indications characteristic of Carlin-type gold mineralization have been examined by a number of geologists, and the more obvious prospects have been tested by surface sampling and drilling. It is likely that most of these readily recognizable deposits have already been found and, as a consequence, prospectors are now entering a new, second stage of exploration for Carlin-type and related disseminated gold deposits.

A Definition of Carlin-Type Deposits

The classical Carlin-type gold deposit, as exemplified at the Carlin mine, contains micron-sized, high-fineness gold particles in a dolomitic siltstone. The mineralization is disseminated in the sense that it occurs more or less randomly in a block whose diameter might be a centimeter, a meter, or up to a kilometer. Randomly, however, does not mean accidentally. The gold occupies specific sites based on the chemistry of deposition and the nature of the structures present at the time of mineralization.

Similar mineralization characteristics, geochemical associations, and related structural fabric have been observed in a number of rock types; hence the term "Carlin-type" has been extended to cover a wide range of disseminated gold occurrences in a variety of host rocks (to the dismay of purists in the field). It is this wider spectrum of disseminated gold occurrences bearing the prefix "Carlin-type" that is referred to in this article.

The Carlin Discovery

During 1961, Newmont geologists Robert B. Fulton and John Livermore, acting on an idea inspired by a US Geological Survey publication, selected an area in the Lynn window north of Carlin, Nev., for further exploration. The selection appears to have been based on a hunch that the window was caused by an uplift due to the intrusion of igneous rocks at depth. The same intrusives could have accounted for the mineralization.

After a period of mapping and sampling, a drilling program was undertaken and the third hole cut 24 m (80 ft) of gold mineralization assaying over 34 g/t (1.0 oz per st). This intercept marked the beginning of the Carlin mine, and created in its aftermath a gold rush for similar deposits. The mine repaid its investment cost within three years and today continues to provide handsome dividends to its parent company.

Early Exploration Models

Discoveries at Carlin and a few years later at Cortez, Nev., served to emphasize the apparent spatial, if not the genetic, association of gold with the Roberts Mountains thrust fault, a major structural feature in central Nevada.

Courtesy Newmont Mining Corp.

Gold pouring at Newmont Mining Corp.'s Carlin mine in northeast Nevada. The discovery of mineralization at Carlin sparked a gold rush for similar deposits.

Selective erosion removed some of the upper plate rocks, exposing the lower plate carbonate sequence in which is found the Roberts Mountains formation. It was this formation which served as host for both Carlin and Cortez. The quick and dirty exploration model was therefore based on: (1) Presence of the Roberts Mountains thrust fault, and (2) presence of a window which exposes lower plate carbonate rocks.

Because mineral exploration is a highly competitive business and its practitioners seldom wait until all the scientific evidence is in, this primitive model served to establish exploration targets for a number of companies and individuals, and most of the windows were staked and drilled. Some windows turned out to be slide blocks, a surprise to exploration geologists who found that their drill holes seemed to pass from *lower* plate rocks into *upper* plate rocks.

The importance of the Carlin find must have generated some heat within government circles. In April 1966, the US Geological Survey and US Bureau of Mines started what was then known as the Heavy Metals Program. Its

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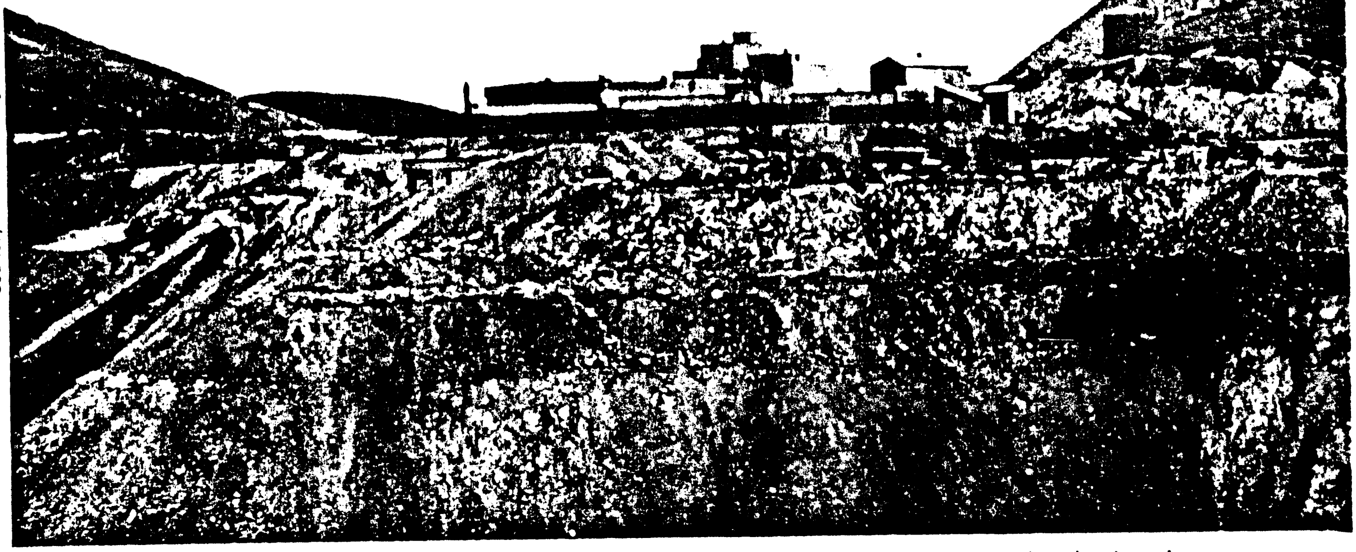


Courtesy Newmont Mining Corp.

The Carlin discovery served as a primitive model for a number of companies establishing early exploration targets.

purpose was to stimulate domestic production of a group of metals in short supply, including gold, silver, platinum group metals, mercury, tin, antimony, bismuth, nickel, and tantalum. An early progress report states that about 90% of the effort during the first year had been on gold because of its "international monetary importance." Evidently, the Survey knew something the Treasury Department did not!

The Heavy Metals Program was a decided stimulus to the exploration for Carlin-type gold deposits, especially in Nevada. In the course of the program, the USGS and USBM published a large number of circulars and maps which, in spite of their uneven quality, did bring out some of the major geologic and geochemical aspects of this type of gold deposit. The program also described the deposits themselves, insofar as they were known at that time.

In 1966, at the beginning of the Heavy Metals Program, analysis of samples collected during earlier surveys indicated a major gold anomaly in sedimentary rocks north of the old Cortez mining district in central Nevada. The Cortez gold deposit was discovered soon after and produced more than 26 400 kg (850,000 oz) of gold before reserves were depleted.

The Heavy Metals Program faded into obscurity in 1970, but it remains an interesting example of a government-sponsored "task force" approach to mineral exploration. On balance, the program can be regarded as successful in achieving its most important objectives. In view of the present worsening supply situation for commodities such as cobalt and chromium, as well as the continued dependence on non-US sources for most of the heavy metals, a revival of the program might be seriously considered.

Development of the Present Carlin-Type Model

Research work, principally at Carlin itself, has resulted in publication of many descriptive papers and maps. The culmination of this work, conducted largely by Arthur Radtke of the US Geological Survey, resulted in preparation of a USGS Professional Paper on Carlin which in mid-1979 was in the review stage.

The depositional model for Carlin is relatively straightforward, with mineralization the result of hydrothermal processes. Fluids were guided by pre-existing structures and the gold was precipitated as a consequence of solution boiling and reactions with the host rock in the presence of carbon- and sulfur-bearing minerals. Removal of calcite from the mineralized area was a significant factor, as well as the remobilization of carbon and silicification of host rocks. The extremely fine-grained gold occurs in pyrite grains as well as with other sulfides and with carbon.

The geochemical associations which were developed in the process of studying Carlin and many other similar deposits are among the most powerful exploration tools. There are no magic numbers, but anomalous arsenic and mercury are commonly seen within the gold mineralized zone. A source of exasperation for many exploration geologists who apply geochemical procedures in the search for Carlin-type deposits is the extreme short-range variability in distribution of these associated elements, resulting in anomaly clusters rather than well defined simple anomalies. Whether or not anomalous values extend any significant distance from the center of gold mineralization is debatable, and the halo effect based on geochemistry of the common associates is not as pronounced as may be the case in certain other kinds of ore deposits.

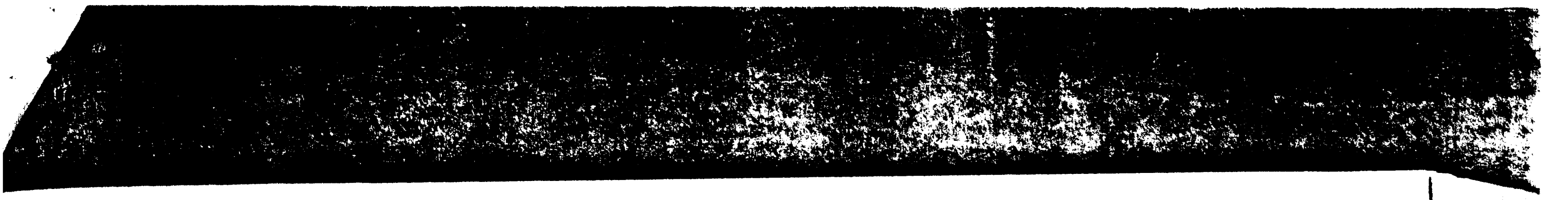
Target dimensions for Carlin-type ore deposits are relatively small. Carlin itself can be contained in a 610 × 215 m (2000 × 7000 ft) ellipse, and Cortez is smaller—915 × 305 m (3000 × 1000 ft). Numerous other similar occurrences are smaller still. Clearly identifiable partially mineralized zones adjoining ore-grade or near-ore-grade rock are difficult to recognize, and it is in this area that the next generation of exploration must concentrate.

The Next Exploration Stage for Carlin-Type Deposits

Exploration for Carlin-type gold deposits has entered a stage where much of the effort is being expended on analyzing mineralized and altered areas that are partially covered by post-ore gravels or volcanics. These areas may have their primary ore zones buried, leaving only the less well understood halo area available for prospecting.

The situation is analogous to the development of exploration models for porphyry copper deposits. Prior to the mid-1950s geologists only vaguely understood the alteration and zoning patterns surrounding porphyry copper deposits. The intense exploration and research efforts of the 1950s and 1960s developed explicit exploration models with clear descriptions of geologic and geochemical features, as well as providing a good fix on the geophysical characteristics. Several important papers are now available on the subject.

The exploration model for Carlin-type gold deposits is not yet as well understood as that for porphyry copper deposits. There are sufficient criteria available to evaluate



an outcropping ore zone, but not for identification of the geometry and characteristics of the primary zones surrounding the ore. The incomplete nature of this information is part of the challenge facing explorationists who search for gold.

Since the discovery of Cortez, no sizable new Carlin-type gold deposits have been put into production although a few potentially valuable gold reserve discoveries have been reported. The most substantial recent discovery is at Marlboro Canyon in north central Nevada. Freeport Minerals, working on an earlier discovery made by FMC, has announced developed reserves of 4.5 million tons (4.9 million st), with a grade of 10 g/t (0.3 oz per st). A $60-million capital investment for an 1815 t/d (2000 stpd) mine and mill complex is in the planning stage, and production may start in 1982.

Elsewhere in Nevada, Selco and Occidental report a discovery of 5 million tons (5.5 million st) at a grade of 3.4 g/t (0.1 oz per st) of gold, however details of the geology are no[illegible]own. Gold reserves are also reported at the Getchell an[illegible]inson areas, Windfall, Northumberland, and 22.5 km (14 miles) south of the Carlin mine. The general locations of a number of disseminated and Carlin-type gold occurrences are shown in the figure below, and the table summarizes production and reserves for six of the more important mines and prospects.

Intensive exploration has resulted in a close look at several outcropping deposits that had been known from prior mining efforts in the same area. Most of the more obvious gold targets have also had the benefit of surface exploration and many have been drilled. The second stage exploration problem now resolves itself into evaluation of geologic and geochemical features in small outcrop areas that have a vague resemblance to Carlin-type mineralization, but also have some notable differences.

Some Exploration Concepts

The approach to the second stage of exploration for Carlin-type deposits can be based on an extension of the knowledge gained from the known deposits. A few conce[illegible] for exploration are suggested below.

Mass chemical effects: In carbonate rocks, the ore-forming process for Carlin-type deposits is attended by considerable movement of the calcium ion. In some instances, calcite may form a mineralogical halo which, if recognized, can be a guide to the center of mineralization. The problem is to develop criteria for recognition of calcite formed by this process in contrast to calcite formed during normal sedimentation, diagenesis, and weathering. In noncarbonate rocks this effect is less well developed, but even so the movement and redeposition of calcite is recognizable. The movement of silica and carbon also occurs during the mineralizing process, and analogous hypotheses can be developed to guide ore search.

Compound geochemical effects: Bulk rock geochemistry is a commonly used method of prospecting and evaluation, and the use of arsenic and mercury has been mentioned. A compound geochemical effect, as the term is used here, refers to the geochemical suites characteristic of certain individual or closely related mineral species, e.g., the presence of gold in pyrite or antimony in orpiment. These and several other examples are known from isolated field and laboratory studies and may be useful in predicting geochemical patterns in the exterior zones of hidden Carlin-type gold deposits.

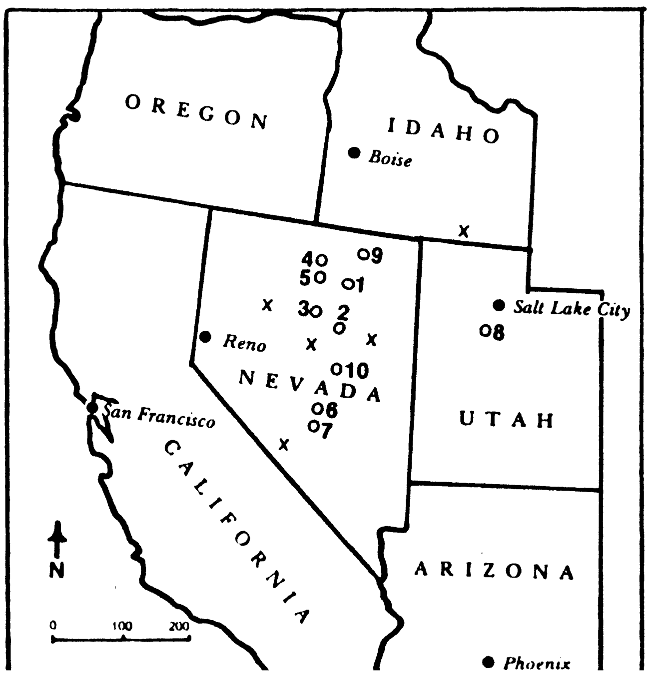
Thermal center association: The thermal history of some of the Carlin-type deposits is now better understood, and this information may lead to prospecting guides in covered or partially exposed areas. Determination of chemical composition and trace element content of spring water is a well known prospecting method. The same concept can be extended to include analysis of the alteration and deposition products of fossil thermal areas to determine if the environment was conducive to transport of gold during the life of the hot spring activity. As an example, the characterization of a spring or eroded altered area formed around an extinct spring as being due either to alkaline or acid solutions is an early step in defining the priority for further work in the area.

The concepts outlined here are a sampling of techniques for searching out and evaluating the hidden occurrences of Carlin-type mineralization, and by no means exhaust the list. The literature and the rocks are full of hints on how to approach this second stage of exploration for Carlin-type deposits. Rigorous attention to geological details and chemical laws will result in measured ore reserves and immeasureable satisfaction for the geologist, the miner, and the stockholder. □

Examples of Carlin-Type Gold Occurrences in the Western US

1. Carlin, Bootstrap, Blue Star
2. Cortez
3. Gold Acres
4. Getchell
5. Pinson-Preble
6. Northumberland
7. Manhattan
8. Mercur
9. Marlboro Canyon
10. Windfall

x Other occurrences



Production Data for Carlin-Type and Disseminated Gold Deposits

Mine	Total Production (oz Au)	Reserves (million st)	Grade (oz/st)
Carlin	2,911,500	6.1	0.20
Cortez	862,213	0	—
Gold Acres	+400,000	minor	0.20
Getchell	314,000*	5.0*	0.10*
Northumberland	35,000	+2.0*	0.15
Pinson and Preble	0	1.7	0.18

*=estimated