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Paper #31

GEOLOGY AND DEVELOPMENT OF THE RELIEF CANYON  
GOLD DEPOSIT, PERSHING COUNTY, NEVADA

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: Lacana Chairman Dr. Bill Gross, President Ed Thompson, Chief Engineer Colin Marshall, Vice-President Harvey Sobel, and Exploration Manager Mike Easdon.

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## INTRODUCTION

The Relief Canyon Project involves development of open-pittable, disseminated, epithermal gold metallization. The project site is roughly 20 miles northeast of Lovelock, Nevada, along the southwestern margin of the Humboldt Range. The Rochester Silver District is 5 miles north of Relief Canyon and the Antelope Springs Mercury District is to the immediate south.

Gold occurs within and proximal to jasperoidal silicification developed principally within a sedimentary breccia unit underlain by Late Triassic platform margin carbonates and overlain by Late Triassic pelitic deltaic rocks.

Lacana and another company are both developing this deposit which contains greater than 8 million diluted ore tons with an average grade of 0.04 oz Au/ton. At a waste to ore ratio of 1.5, the anticipated annual ore production will approximate 1 million tons.

Results of both bench scale metallurgical tests and a comprehensive heap leaching project suggest that gold recoveries exceeding 65% may be sustained without crushing and agglomerating the ore.

The project is very well located with respect to the availability of water, power, and labor. The topography is excellent for a mining and milling operation. Projected capital and operating costs are favorable. Final feasibility analysis and design engineering will commence in February, 1984.

## REGIONAL GEOLOGY

### Lithology

Six major rock groups are exposed in the southern Humboldt Range. In order of decreasing age, these are volcanics of the Koipato Group, marine carbonates of the Star Peak Group, terrigenous clastics of the Auld Lang Syne Group, a gabbro and diorite intrusive complex, a quartz monzonite intrusive complex, and young alluvium and volcanics.

Permian-Triassic volcanics of the Koipato Group form the regional basement. The upper portion of the Koipato consists of rhyolitic tuffs intruded by boron and fluorine enriched leucogranite and rhyolite porphyry considered by Vikre (1981) to be of the same origin as the tuffs. These rocks contain more than 100 million tons of low grade, disseminated, and vein controlled precious metals mineralization in the Rochester Silver District.

Early to Late Triassic calcareous marine strata of the Star Peak

Group were deposited upon islands or peninsular basement highs of the Koipato volcanics. Nichols and Silberling (1977) indicate that nearly 4000' of basinal, slope, shelf, and platform carbonates and subordinate terrigenous clastics and volcanics record eastward marine encroachment upon the Koipato.

Approximately 25,000 feet of Late Triassic argillite, arenite and subordinate limestone of the Auld Lang Syne Group were rapidly deposited unconformably upon the Star Peak Group as regional uplift and deltaic sedimentation occurred, according to Burke and Silberling (1973).

Following deposition of the Auld Lang Syne Group, orogenic activity resulted in widespread intrusion of Jurassic gabbro, diabasic quartz diorite, and amphibole-pyroxene-magnetite diorite, as described by Johnson (1977).

Younger intrusions of Cretaceous granodiorite and quartz monzonite are rarely present in the southern Humboldt Range, but Vikre (1981) concluded that these rocks probably underlie the Rochester Silver District.

Post-Mesozoic rocks exposed in this region include Tertiary alluvial deposits and Quaternary basalt flows and younger alluvium.

### Structure

The Jurassic-Cretaceous Nevadan Orogeny is reported by Johnson (1977) to have caused extensive low grade regional metamorphism of rocks exposed in the southern Humboldt Range. Complex folding and minor thrust faulting was probably coeval with the emplacement of Jurassic gabbro and related intrusives. The folding event is obvious in the field, but the thrust faults, where examined in the field, are obscure, and in places, dubious.

Two intersecting major structural zones of Late Mesozoic to Tertiary age are present in the region. The possibly older of the two zones is exactly coincident with the Rye Patch lineament described by Rowan and Wetlaufer (1981) as a major northwest trending right lateral strike-slip system. It forms a topographically pronounced, sub-parallel, linear fault belt of at least 5 miles width and transects the southernmost portion of the Humboldt Range and the northernmost portion of the West Humboldt Range.

The other and probably younger fault system is the northeast trending Humboldt Structural Zone considered by Trexler and others (1979) to be a left lateral shear which transects most of northern Nevada. It forms the western margin of the West Humboldt Range. A parallel structure, the Black Ridge fault, defines the western edge of the southern Humboldt Range and is considered by Vikre (1981) to be a normal fault of great displacement dipping westerly.

Examination of the Pershing County geologic map by Johnson (1977)

suggests that a significant right lateral component to the Black Ridge fault might exist. If so, it is possible that the mineralized rocks exposed at Relief Canyon may have once been positioned vertically and horizontally proximal to the Rochester District.

## LOCAL GEOLOGY

### Lithology

The gold deposit at Relief Canyon occurs at the contact between the Cane Spring Formation, the uppermost unit of the Star Peak Group, and the overlying Grass Valley Formation, the lowest unit of the Auld Lang Syne Group. Strata-bound and conformable mineralization exists principally in a local sedimentary breccia. This unit appears to be a polymictic debris flow of intraclastic and possibly fluxoturbidite breccia of marine origin.

Drilling indicates that the highly irregular debris flow occasionally exceeds 200' in thickness and is unconformable with the underlying platform-margin carbonates of the Cane Spring Formation.

The Cane Spring Formation contains thinly bedded, silty, carbonaceous, and bioclastic limestones in its lower portion and thickly bedded, occasionally recrystallized micrites and weakly bioclastic limestones in its upper portion.

The debris flow appears to be unconformably overlain by micaceous, feldspathic, and quartzitic subphyllitic argillites and arenites of the Grass Valley Formation. Burke and Silberling (1973) conclude the Grass Valley to be the basal portion of a large, westerly prograded deltaic complex. Soft sediment deformation textures are present in the Grass Valley, particularly near its basal contact with the debris flow.

The debris flow comprises crudely stratified and rarely graded beds of subangular to subrounded clasts of greatly variable sizes trapped within a clay and mud matrix. Common fabrics of the breccia include both interlayered and massive zones of dominantly matrix supported, rarely imbricated clasts in clayey, silty or sandy matrix material. Fragments of micrite with rip-up clasts are common. Slabs and blocks of limestone several hundred feet in maximum dimension occur as mega-clasts surrounded by finer grained breccia or resting directly upon the Cane Spring Formation.

Clast lithologies are identical to strata of the Grass Valley and Cane Spring Formations. Evidence of multiple episodes of transport of the debris flow, prior to its complete lithification, is common. Large and small scale soft sediment deformational textures are occasionally recognizable.

Within the drilled area, the debris flow appears to be an irregular triangular wedge or bell-shaped mass in plan, the apex of which is located at the center of the east margin of the gold deposit. The Black Ridge fault probably terminates the breccia to the west, but drill confirmation of this does not yet exist. The debris flow is absent east of the apex and it is terminated to the northeast by strongly altered diorites which occupy an older, high angle, northwest trending fault system. Footwall limestones of the Cane Spring Formation are present on the northeast contact of the diorites.

Structural contours of the base of the Grass Valley may reflect the Jurassic-Cretaceous folding event of the Nevadan Orogeny. However, many small, irregular, divergent folds are superimposed upon a broad, open, northeast trending antiform which plunges southwesterly. It is currently unclear whether any or all of these folds might reflect original emplacement geometries of the debris flow.

#### Origin of the Debris Flow

Our current working hypothesis regarding origin of the debris flow fundamentally involves minor movement along the fault now occupied by diorite intrusives as very rapid loading of deltaic sediments occurred upon poorly lithified micrites. Such movement may have induced sub-horizontal shear failure of the water-rich, unlithified or poorly lithified calcareous oozes. The importance and mechanics of earthquake induced slumping, liquifaction, and plastic deformation as a result of rapid sedimentation is discussed by Morgenstern (1967), Dott (1963), McIlreath and James (1978), and other referenced authors. It is unknown whether failure along the delta front occurred or if failure occurred along the margin of a submarine channel, or other similar escarpment.

Because slumping and detachment involved both the Cane Spring and Grass Valley Formations, it is likely that the poorly lithified deltaic sediments were left largely unsupported on their western basinward margin. This concept coupled with the observations of soft sediment deformation in the base of the Grass Valley and its apparently unconformable relation to the debris flow suggests that it was locally emplaced by gravity sliding upon the debris flow. Renewed deltaic sedimentation then continued.

#### Mineralization and Alteration

Economically recoverable gold mineralization, principally as native gold or electrum, occurs most commonly as thick strata-bound lenses within the debris flow proximal to its contact with the Grass Valley Formation. Irregular zones of mineralization are present in minable quantities in the Cane Spring Formation also, but rarely present in the Grass Valley.

Permeability of the debris flow was a major factor in the mineralizing process. Hydrothermal fluids were effectively trapped under basal shales of the Grass Valley and migrated laterally under low hydrostatic pressures, favoring the silty and sandy zones of the debris flow. Mineralization of the larger limestone clasts occurs along their margins and in small fracture networks within the clasts.

The bulk of the mineralization occupies the crest of the broad northeast trending, southwest plunging antiform described earlier, but smaller subsidiary folds also provide important structural controls.

Two visually obvious alteration features present at the surface include large, resistant outcrops of jasperoid and widespread iron oxide staining. Where not intensely silicified, the breccia is mostly sericitized and weakly silicified. Argillization appears to be uncommon, but small quantities of kaolinite and montmorillinite have been identified.

Except in rare instances, the breccia is strongly and completely oxidized, probably by hypogene fluids. Most of the Cane Spring Formation is also well oxidized.

At the surface, the diorite intrusives are not only extensively oxidized, but are also propylitized. Quartz, calcite, serpentinite, talc, hematite, and pyrite are common alteration products observed in drill cuttings of the dikes.

#### Paragenesis and Geochemistry

By way of thin section, polished section, and scanning electron microscope analyses, Bruha (1983) concluded that at least five stages of mineralization have occurred at Relief Canyon.

The first stage involved minor brecciation and widespread introduction of quartz, pyrite, and sericite. These minerals initially nucleated on calcite shell fragments in the limestone clasts and along cleavage planes in the siltstone clasts, but were finally deposited as broad disseminated bands throughout the clasts and matrix.

The second stage involved minor brecciation and localized veining of quartz, MnOX (?), talc, and amorphous primary hematite.

The third stage involved brecciation and fracturing with introduction of flaky primary hematite and drusy quartz.

The fourth stage involved brecciation and very severe hypogene oxidation of all previously deposited minerals. This produced hematitic selvages on breccia fragments and hematitic banding in the matrix. Deposition of amorphous hematite upon previously developed pseudomorphs of hematite after pyrite also occurred as extensive solution banding

of original breccia clasts developed.

Deposition of zoned fluorite may have begun as early as the third stage of mineralization, but this is unclear.

The timing of gold deposition is also unclear, but it may have followed the third stage and terminated by the end of fluorite deposition. Electrum commonly fills tiny vugs or occurs with amorphous hematite. Clear evidence of gold associated with pyrite does not exist, nor has silica encapsulation of gold particles been observed. Most gold particles are 2-4 microns in maximum dimension.

Elements commonly associated with gold are silver, fluorine, arsenic, antimony, and mercury. One peculiar feature observed in polished section is an apparently late stage mineraloid containing minute crystals of sulfides of Cs-La, Pb, Zn, and Cu.

Homogenization temperatures of saline fluid inclusions in fluorite range between 160-187 C, indicating a minimum hydrostatic head of less than 300 feet.

Age of the mineralization is unknown and datable minerals have not been found. Field relations indicate a range of possible ages from Late Cretaceous to Late Tertiary. An interesting question is whether the mineralization at Relief Canyon is related to that of the Rochester Silver District, determined by Vikre (1981) to be Late Cretaceous in age.

## DEVELOPMENT

### History

The Relief Canyon Project site was originally known as the Emerald Spar fluorite prospect and minor exploration of surficial fluorite occurrences was done in the early 1940's according to Papke (1979).

In 1978, Falconi and Associates, an engineering firm based in Auburn, California, staked 4300 acres of claims at the site of the Emerald Spar prospect. Falconi's innovative intention was to develop a cement plant to service anticipated construction of the federal government's MX missile project.

In 1979, Jim McKee of Duval Corporation initiated an aggressive precious metals exploration program in the Humboldt Range, which involved mapping and stream sediment sampling. A single sample assaying 0.45 ppm Au was collected at the mouth of the main canyon transecting the gold deposit. With detailed mapping and sampling, Jim identified large zones assaying .01-.06 oz Au/ton. In 1981-82, Duval drilled 38 reverse circulation percussion holes and confirmed the existence

of a low grade, but potentially minable zone 2400' long by 1800' wide.

In the fall of 1982, Lacana Vice President Harvey Sobel and Reno Exploration Manager Mike Easdon reviewed the project data at Duval's Tucson office and immediately recommended the property for acquisition. Lacana President Ed Thompson negotiated a well-balanced option agreement with Duval and we immediately commenced bench scale metallurgical tests. Lacana now owns 100% of the original Falconi farmout.

### Drilling and Metallurgical Tests

After receiving re-assay confirmation of Duval's drilling results and numerous cyanide leaching tests on the drill cuttings, we proceeded to cut a series of deep trenches for large metallurgical samples. Upon collecting approximately 2.5 tons of various ore-grade material, a battery of cyanide bottle roll, column leach, barrel leach, assay screen analysis, agglomeration, crushing, and gravity concentration tests were conducted. The principal labs involved included Dawson Metallurgical Lab in Salt Lake City, Kappes-Cassiday Associates in Reno, and Hunter Mining Lab in Reno.

The following results were indicated: cyanide leach recoveries ranged between 50-90% at a rapid leach cycle with low to moderate reagent consumption; a particle gold problem was not observed; agglomeration might enhance percolation; point to point assay variation among samples could be large, but the overall average grade indicated by Duval's drilling was preserved.

With this encouragement in hand, we immediately commenced detailed geological mapping and systematic drilling on 200' centers to evaluate the indicated geological reserves. 48 reverse circulation percussion holes were completed by Eklund Drilling Company of Elko by the spring of 1983. Upon compiling the drill assay data, we learned that our potential reserve calculations very closely matched our geological reserve calculations based on Duval's work.

Upon completion of our first drilling phase, we decided to proceed with a pilot-scale metallurgical test in the field. Many well known metallurgists and experienced operators including Lacana's Chief Engineer Colin Marshall, Don Duncan, Robert Shoemaker of San Francisco Mining Associates, Harris Salisbury of Dawson Metallurgical, Bruce Thorndycraft of Pinson, and Bruce Brogoitti and Ash Patwardan of Mine and Mill Engineering contributed to the process engineering and pilot plant design.

We decided to mine and cyanide heap leach two 5000 ton ore blocks. The mining sites of these ore blocks were chosen to be representative of not only the bulk of the gold deposit, but also of material we knew would be mined during the pay-back period of the project.

Bob Hoover of Bo-Ter Construction Company was contracted to mine the ore and construct the leaching facility, crushing plant, and recovery circuit according to final design engineering provided by Mine and Mill Engineering.

Four potential mining sites were chosen and drilled on 25' centers by reverse circulation. Two of these potential sites were then selected as being adequately representative and overburden stripping began simultaneously with plant construction. Upon completion of the strip, all of the in-place heap leach ore was drilled on 3'-5' centers for blastholes. A composite sample for each blasthole was collected and assayed. Additionally, a composite head sample split of approximately 1000 tons was cut from the original 10,000 tons of mined ore as it was delivered to the pilot plant.

Ore from the two mining sites was mixed and roughly 4700 tons of run-of-mine ore was loaded on the first pad by front end loader and dozer. Dilute cyanide solution was immediately applied to this heap.

The remaining 4300 tons of mined ore was crushed to nominal - 3/4" and periodically sampled. Approximately 7 lbs. of Portland cement and 1 lb. of NaCN per ton of ore were added to the crushed rock. 12 weight percent water was added to this mixture as it was rotated in a drum agglomerator. Upon curing of the cement, the agglomerated ore was loaded onto the second pad by front end loader and leached.

Performance of the agglomerated ore heap has been excellent in terms of rate of gold extraction, percolation, and gold recovery. Recovery to date has exceeded 75% of the contained gold.

Similarly, performance of the run-of-mine ore heap has been outstanding also. Slight ponding occasionally occurred, but solution channelling is not evident. To date, this heap has an indicated recovery exceeding 65% of the contained gold.

Fill-in drilling on 100' centers commenced in late summer of this year and we expect to be finished with our final drilling program by the end of the year. This work has allowed us to refine both the geometries of the ore blocks and our geological interpretations. Preliminary evaluation of the newer drilling data suggests that both grade and tonnage of our original potential reserve calculation have decreased by a factor of approximately 5%.

We estimate that by the end of this year, approximately 400 holes will have been drilled by Duval, Lacana, and an adjacent property owner to fully define the deposit.

### Production Plans

As earlier mentioned, Lacana and another company are developing the deposit. Joint venture negotiations will soon be finalized. Lacana will operate the venture. Production could commence as early as summer of 1984.

The trend of the deposit remains open to the southwest, but it is currently untested. It appears likely that as mining proceeds, development drilling of this region might expand the estimated 8-year mine life.

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