Study of Vein and Fault Structures

North East Galena Hill – Christal Lake Area

Galena Hill - Keno Hill Silver Camp

Central Yukon

NTS 105 M 14

Latitude 63° 55" N; Longitude 135° 21" W

For

Access Mining Consultants Ltd
Whitehorse, Yukon

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Figures (Illustrations)

1.0 INTRODUCTION

The Galena Hill and Keno Hill silver camp has silver, lead and zinc veins cut by later faults. Both veins and faults can contain ground water often anomalous in zinc and in some places anomalous in other metals.

The writer is familiar with the geology of this silver camp, having worked in total about 5 years for United Keno Hill Mines [UKHM], first in the mid 60s and again in the mid 1990s. During the later period, the writer prepared the geology plans included in the UKHM water licence application prepared by Access Mining Consultants of Whitehorse. The plans and information in the water licence application were used for this report. Additional information was taken from Geological Survey of Canada publications listed in the references. Bulletin 111 1965 by R. W. Boyle [5] gives an excellent description of the silver mines and occurrences, as well as geochemical data on rock types, mineralization, soils, vegetation and ground water. Some historical information was provided by Alan Archer who was Chief Geologist at UKHM from 1957 to 1966 and from Fulvio Roberti who worked at the site from 1957 up until November 2001. Historical and geological information appearing in the unedited manuscript [1980s?] describing this silver camp by the late Dr. Aro Aho was also used. In September 2001 AMT Canada Inc. acquired through a Supreme Court order the assets and property of UKHM.
This unsolicited report was written to provide assistance for the mine operators and regulators to have a better understanding of ground water movement in this area.

The writer would like to thank Mr. Rob McIntyre of Access Mining who helped interpret for the writer some of the past technical information and prepared the base plans. As well, my thanks to Ms. Lori Walton and Mr. Jim McFaull who reviewed a draft of this report and offered many helpful suggestions.

The rough hand drafted plans have been used for this report, as funds were unavailable to produce a final drafted version.

This report will start with a brief geological overview of the silver camp and follow with specific detail on the silver mines and occurrences in the study area.

2.0 GEOLOGY OVERVIEW

In general, the veins in the Galena Hill-Keno Hill area strike northeast and dip steeply [65 - 75°] to the southeast; and are mineralized by varying amounts of galena, sphalerite, tetrahedrite and pyrite in a siderite/minor quartz matrix. Some veins contain mostly native silver and/or sulpho-salt silver minerals in the orebodies. The veins are hosted by quartzite interbedded with quartz graphite schist/phyllite. Most of the silver occurs in galena as microscopic tetrahedrite and sulpho-salt minerals. Mineralization occurs in two distinct zones. The upper oxide zone varies from a few tens of feet up to 600 ft. below surface. The zone formed as a result of movement of ground water down and along the vein and subsequent oxidation of metallic minerals and siderite to form various oxides, sulphates, and carbonates of iron, lead and zinc. Siderite, pyrite and sphalerite are the minerals most affected by oxidation and galena is the least affected. Some veins at the base of the oxide zone contain enriched lead and silver content. Below the oxide zone is the hypogene zone where the vein has been largely unaffected by oxidation. The contact between the two zones is transitional. At some mines individual orebodies in the hypogene zone show a noticeable increase with depth in pyrite and sphalerite content. Ore bodies by definition are where economic concentrations of mineralization are present. The favourable location for ore bodies is at the junction of two or more veins and where the veins are hosted by competent thick-bedded quartzite. Ore bodies can be up to 30 ft wide but normally are in the order of 5 to 10 ft. Between the ore bodies the veins are narrower, - less than 5ft in width, and contain low-grade mineralization commonly less than 3-5 oz./ton silver. Throughout the camp only 10- 15% of a vein has ore-grade mineralization. The veins are cut and horizontally displaced by right handed northwesterly striking and southwesterly dipping faults. Two types of faults are present, cross faults and bedding plane faults. Cross faults show a moderate to steep dip [45-75°]. The bedding plane faults are flatter in dip [~30°] and are called bedding plane faults as they are parallel or at an acute angle to the bedding of the quartzite and quartz graphite schist/phyllite. The cross faults vary from less than a foot wide with little displacement, to 150 ft. in width consisting of individual faults in an envelope of moderate to strongly fractured rocks. Most of the stronger cross faults have a horizontal displacement of 50 to 400 ft, although right hand displacement of up to 2,000 ft. has been noted. Fault movement has crushed and pulverized the rock to clay that inhibits the water movement along the fault plane; however, water is often in the permeable fractures around the fault. The faults along strike may have reduced displacement and eventually become a wide fracture zone with little apparent displacement.

Pleistocene glacial deposits composed of gravel, sand, and clay, cover all but higher elevations. These would average 10-20 ft. thick, however in some of the creeks and gulches thicknesses in the order of 30-50 ft. thick are found. In the main valley floor the glacial cover exceeds 150 to 300 ft. in depth.

Permafrost is patchy in its distribution, depending upon the elevation, hillside exposure, depth of overburden, amount of vegetation and presence of moving underground and surface waters. North facing slopes mostly have the ground permanently frozen, whereas south facing slopes are frost free in summer. At the Keno Mine on Keno Hill underground workings encountered permafrost to some 400 ft below surface and at the Bellekeno Mine on Sourdough Hill frost and ice veins were found in the mine workings to 250 ft below surface. On Galena Hill permafrost has been found to depths of 200 ft or more below surface.

Below the permafrost underground water comes into the mine workings from the veins and faults. The origin of this water is uncertain but it is probable that it represents surface water that has gained access to the veins and faults where permafrost is absent. The water channelled into the veins and faults comes to surface year-round as springs at lower elevations where permafrost is absent. Water in creeks is derived from rainwater, snowmelt and melting in the active layer of permafrost which extends in the summer months to about a foot below surface.

The first silver deposit found in the Galena Hill-Keno Hill silver camp was the Silver King in 1906. Production at Silver King Mine started in 1912. Since then, total production from 35 mines and showings has amounted to 5.3 million tons of ore grading 40.0 oz./ton silver, 6.55% lead and 4.09 % zinc. Some 50% of the tonnage and 45% of the silver has come from the Hector-Calumet Mine.

3.0 MINES AND VEIN OCCURRENCES

3.1 Hector-Calumet Mine [See Figures 1 and 2]

3.1.1 History

The 1 vein was first staked in 1920, but ore was not discovered until 1934-35. Treadwell Yukon, who operated the mine from 1936 to 1941, processed the ore from this vein at a mill located in Elsa. During this period the 400 level adit was driven to the vein. Treadwell Yukon closed their operation in 1941 because of World War Two. The mine was purchased by and reopened in 1945 by Conwest who formed United Keno Hill Mines Limited [UKHM]. From 1947 to1951, mining was confined on and above the 400 level. In 1951 the rich No 3 vein, with widths up to 12 ft. of massive galena, was discovered. This discovery prompted UKHM to sink the No. 3 internal shaft from the 400 level and completed it to the 1300 level in October 1954. This shaft allowed the exploration and mining of ore shoots on 6 levels, each about 125 ft. apart, below the 400 level. The 1165 level is the lowest development level at Hector-Calumet. After UKHM purchased the Galkeno Mine a connection was made from it to the Hector-Calumet 750 level. When underground ore was exhausted in October 1972, the mine was shut down. In the 1980s mining from three open pits-Calumet 1-15, Hector and 4-11 was carried out. The deepest open pit, Calumet 1-15 mined ore to about 135 ft below surface.

3.1.2 Geology

The vein system has been explored over a strike length of 7,000 ft. and vertically to about 1,200 ft. below surface. The Hector-Calumet is the deepest mine in the camp. The Hector and Calumet faults have cut the veins into three segments. The 3 –4 veins occupy the southwest segment, the middle segment by the 1 – 2 –15 veins and the segment to the northeast by the 18 – 19 veins. Mineralization in the veins is essentially the same as most of the deposits in this camp. Lenses of mineralization 10 ft. or more in width are common. Where two ore bodies are close together, silver grades between them are generally high enough so that both the ore bodies and rock between them is mined. This leads in the above circumstances to mining widths up to 50 ft. This is one factor that made Hector-Calumet the highest producer in the camp.

3.1.3 Oxide Zone

At the Hector-Calumet, the oxidation zone extends down to 600 ft. below surface on the 1 and 2 veins and to 400 ft. on the 3 vein. Boyle [5], who assayed representative composite ore samples taken from the 100 level to 900 levels on the 3 vein, showed that at the 100 level most of the zinc has been removed [0.52% present], and on the 300 level about 50% [6.4% zinc present] of the zinc has been removed. The zinc content in the hypogene zone, below the 400 level varies from a low of 11.2% on the 525 level to a high of 24.4% on the 900 level. The base of the oxide zone is some 200 ft deeper on the 1, 2 and 15 veins than on the 3 vein. This writer suggests that increased open fractures in and around the vein would allow the passage of ground water. Just above the 400 level, on the 1-15 veins mining exposed a 30 ft. wide zone on the veins where intense oxidation has reduced the vein and country rock to a weakly consolidated sand with sulphides absent. Production from the 1-15 open pit show the zinc content at 0.20%, an almost complete removal of the zinc to some 135 ft. below surface.

3.1.4 Faults

Three major northwest striking, moderate to steep southwest faults cut across and displace the Hector-Calumet veins. The three, from southwest to northeast are the Jock, Hector and Calumet. These faults are up to 150 ft. wide and dip from 45° to 60°to the southwest. The Jock fault has a horizontal displacement in the order of 400 ft. and extends to the No Cash Mine located about 4,000 ft. northwest of the Hector- Calumet Mine. There it is called the No Cash fault and has a horizontal displacement of 60 ft and is the principle source of water at the No Cash Mine. On the south east facing slope of the Duncan Creek valley, about 4500 ft. southeast of Hector-Calumet, is a prominent linear represented as a gully. This linear may represent the surface trace of the Jock fault. The Hector fault has a horizontal displacement of some 270 ft. To the south east of the Hector-Calumet Mine the inferred surface trace of the Hector fault cuts the Eagle vein near this showing and the upper part of McLeod Creek. The Calumet fault has a horizontal displacement of 320 ft. in the main mine workings. The fault was also intersected in the underground working of the Hector-Calumet 4-23 North Drift, about 1500 ft. south east of the main mine workings. About 2,000 ft. southeast of the 4-23 North Drift, the surface trace of the Calumet fault cuts across the head of Hinton Creek. Further to the southeast the surface trace cuts across McLeod Creek. The Calumet fault is the probable year-round source of water in these two creeks.

3.1.5 Mine Water

Boyle [5] found at Hector-Calumet that the zinc content of water issuing from or near veins on the Hector and Jock faults varied from a low of 50 ppm to a high of 80 ppm zinc. The arithmetic average is 64 ppm zinc. One water sample taken in the hypogene zone on the 650 level at Hector-Calumet assayed 3 ppm zinc. Boyle [5] also reports that a water sample, taken in the mid 1950s, of mine water discharging from the 400 level adit assayed 40 ppm zinc. Both Archer and Roberti said that the veins and the faults provide equal amounts of water. Accurate information on the source of mine water and amount discharged outside Hector-Calumet is absent. Records show the No. 3 internal shaft was dry to 940 ft. At this point water flowing from the Hector fault intersected in the shaft. Between the 1165 and 1300 levels in the shaft strong water flows, up to 100 gpm [~ 6L/sec.], issued from fractures. Flows continued undiminished after the shaft was completed. Fulvio Roberti said that the shaft bottom was always very wet. He estimates about 50L/sec was pumped out of the shaft bottom water sump and discharged at the 400 level portal since the shaft was completed. Of this total, some 20L/sec. was collected for underground use, for the camp, and for a coal fired boiler plant that supplied steam heat for the campsite. In October 1967, the town site was shut down and people relocated to Elsa. Boyle [3] reports that the mine water discharged at the 400 level portal assayed 40 ppm zinc. The discharge mine water flowed across a bog that effectively removes most of the zinc. At a point about 2000 ft. from the adit, discharge water assayed 0.01 and 2 ppm zinc. The total amount of zinc discharged at the 400 level adit is calculated at ~ 63,800 kg. for the period 1956 to October 1972, assuming flows at 30L/sec and containing 40 ppm zinc.

If one assumes that 95% [40 -2= 38 ppm] of this zinc has been retained by the bog moss and organic material, then, the bog contains ~60,600 kg of zinc. By the mid 1970s flooding of the lower working had raised the water table to the 775 level and water was discharging into the Galkeno Mine 300 level. The increase in the zinc content of the adit water indicates that the water moves down the McLeod vein and fault to discharge at the Galkeno 900 level adit.

Most of the stopes at Hector-Calumet have been backfilled with waste rock to provide ground support. Often the backfill was low-grade vein material from an exploration drift or low-grade ore from the stope. This backfill material is generally finely broken which would promote the zinc going into solution by water traveling from surface to the water table at the 775 level. The above average snow pack and summer rain in the area within the past two years have contributed to the increased amount of zinc in the ground water. All of the open pits would funnel the water along the veins and faults.

3.2 Galkeno Mine [See Figures 1 & 3 to 5]

3.2.1 History

The Galkeno mine workings are on four separate veins – McLeod, Sime, 35 and 27 [Sugiyama]. The four veins were discovered in the mid to late 1920s and explored with pits, trenches and shallow underground workings. All four veins were acquired by Mackeno Mines in 1950 who carried out underground development and mining until 1958. All four veins are connected to surface by the 300 level adit. Ore was processed at a mill built in 1953 and located near the northeast shore of Christal Lake. Tailings from the mill were discharged into Christal Lake. Mackeno in 1957 changed its name to Galkeno Mines and in 1958 the property was sold to UKHM. In the early 1960s work resumed on the 900 level adit that had been started by Mackeno in 1957. About this time an underground heading on the 300 level was driven to connect with the Hector-Calumet 775 level via a 60 ft. raise. Surface overburden drilling southwest of the McLeod shaft has outlined a low grade silver [3-4 oz/ton] resource on the McLeod vein that was explored by surface bulldozer stripping ['A' structure]. In 1993 a concrete plug was installed in the 900 level adit to control water flows.

3.2.2 Sime Vein

3.2.2.1 Working

The Sime was explored on four levels [200, 300, 400 and 500] over a vertical interval of about 400 ft. An internal shaft [No. 4] collared on the 300 level connects the three lower levels. On the 500 level a crosscut connects the Sime with the McLeod workings. An estimated 8,350 tons of ore of unknown grade was mined between the 200 and 300 levels. Two open pits [Sime 4&6] permitted mining to 140 ft below surface and along strike for about 1100 ft. From these two pits, 38,128 tons of ore grading 17.43 oz./ton silver, 3.46 % lead and 0.24 % zinc was mined. The bottom of the Sime 4 open pit is about 100 ft above the 200 level and 225 ft above the 300 level.

3.2.2.2 Geology

The Sime vein exposed in the open pits was casually examined by the writer. It is 5 ft wide and contains galena mineralization typical of the camp. No sphalerite or oxidation minerals were noted. In the 900 level adit, the Sime vein may be the vein exposed in the drift located about 350 ft. in the hanging wall of the McLeod vein. The Sime vein southwest of the Sime 6 open pit may correlate with the vein in the Calumet 'C' open pit where 2,392 tons of ore grading 17.88 oz./ton silver, 4.4% lead and 0.24% zinc was mined.

3.2.2.3 Oxide Zone

No concrete information is available to indicate the degree and depth of oxidation. Indirect evidence, as shown below, indicates that the degree of zinc oxidation in the two open pits is strong. Boyle [4] reported that a typical bulk sample of unoxidized ore from the Galkeno Mine – probably from the McLeod vein, assayed 37.03 oz/ton silver, 7.29% lead and 5.05% zinc. The silver/lead and silver/zinc ratios for this sample would be 5.07 and 7.33 respectively. Production from the Sime open pits was 17.43 oz./ton silver, 3.46% lead and 0.24% zinc. The silver/lead and silver/zinc ratios would be 5.01 and 72.6 respectively. Experience at other mines in the camp shows that separate veins in a mine generally have about the same ratios. The silver /lead ratios for the bulk sample and Sime open pit production are almost identical, indicating that little oxidation of the lead has taken place in the open pits. However the two silver/zinc ratios are distinctly different because of the strong oxidation that has taken place in the open pits. A calculated zinc content prior to oxidation using a silver/zinc ratio of 7.3 would be 2.4%. Oxidation in the Sime open pits has removed about 90% of the zinc. It is likely that the base of the oxidation zone is some 250 ft. vertically below surface.

3.2.2.4 Faults

The Sime vein on the underground 300 to 500 levels to the northeast is cut by the "A" bedding plane fault. Horizontal displacement on the fault may be about 40 ft. Projection of the fault down dip, shows intersections at a number of places in the 900 level workings. Faults 'B' to 'E' would also cut and displace the Sime vein. These faults will be discussed in the McLeod vein section

3.2.2.5 Mine Water

The two open pits do not have water pooling in the pit bottoms. The melt of the snow pack in the late spring up until two years ago led to a short surge of water down the vein to the 300 level and then out the 300 level adit. In the summer months water flows out the adit at a rate of less than 0.5 L/sec. The abnormal high water discharged out the adit in the past two years will be discussed at the end of the section on the Galkeno Mine.

3.2.3 35 Vein

3.2.3.1 Workings

The vein was intersected on the 300 level but no vein development was carried out. The only mining on this vein was from a small open pit where production was 9,176 tons grading 25.48 oz./ton silver, 3.83% lead and 0.93% zinc. The pit bottom is about 50 ft. directly above the 300 level adit cross cut to the McLeod vein.

3.2.3.2 Geology

The vein was briefly examined in the bottom of the open pit where it is about three ft. wide and contains siderite with pods of galena.

3.2.3.3 Oxide Zone

The low zinc content [< 1%] of past production indicates that oxidation and leaching of zinc has taken place. The silver/lead and silver/zinc ratios for past production are 6.65 and 27.39 respectively. The 6.65 silver/lead ratio is slightly higher than 5.07 silver/lead ratio for an unoxidized sample results reported by Boyle [4]. This is interpreted as the normal variability seen in silver grades and does not represent oxidation and leaching of lead in galena. The silver/zinc ratio of 27.39 is almost four times that of the Boyle sample. If one uses the silver/zinc ratio from the Boyle sample the pre-oxidation zinc grade would be 3.5%. This shows that about 75% of the zinc has been oxidized and leached.

3.2.3.4 Faults

The surface trace of the 'A' Fault would cut the vein at the north end of the open pit.

3.2.3.5 Mine Water

Water from the spring snowmelt pools at the bottom of the pit but disappears within a month. The water makes its way down the vein to the 300 level and out the adit.

3.2.4 McLeod Vein

3.2.4.1 Workings

The workings consist of a shallow inclined shaft on the vein to the 100 level and adits, now collapsed, on the 100 and 200 levels. From the 300 level adit vein development was carried out on the 300, 400 and 500 levels. A winze connects these three levels and on the 500 level a drive connects to the Sime workings. All the levels are connected by off vein ore passes on vein raises and stopes. The vein drifts were often driven in the hanging wall of the vein because of the heavy quantities of water encountered on the up to 50 ft. wide vein which made on vein development difficult. The workings have exposed the vein over a 2500 ft strike length and over a vertical distance of 600 ft. The lowest level is about 850 ft vertically below surface. Production from this vein was 111,400 tons grading 31.4 oz./ton silver, 6.1% lead and 4.0 % zinc. In 1957 Mackeno Mines collared the 900 level adit about 530 ft below the 500 level and drove it a short distance. The purpose of the adit was to explore the vein but mainly to drain the water from the upper workings. Of interest is that the adit near the portal cut a 100 wide lense of ice in glacial material. UKHM in the early 1960s resumed driving the adit. The initial plan was to continue the adit past the McLeod vein to the Hector-Calumet Mine. The adit would be about 450 ft below the 1165 level. When this adit was about 1000 ft from the McLeod vein a major water flow was intersected. Initial flows had water about 3 ft above the floor of the adit. Work on the adit ceased for a 22-month period for the water to drain. Up until the major water flow was intersected, the adit was dry and drill water was pumped from Christal Lake. The adit was continued to the McLeod vein which is a 50 ft wide zone of highly brecciated rock, often with water-bearing sections that are crushed to a sand and clay gouge. Timbers to support the ground were crushed by the weight of the rock. Poor ground conditions in the vein made it necessary to have the exploration workings paralleling and in the hanging wall of the vein. It was decided to abandon the adit because of the poor ground conditions. No mining was conducted by UKHM on the McLeod vein.

3.2.4.2 Geology

The writer is not familiar with this vein. An unusual feature of the McLeod vein is strong post ore faulting along the vein which has resulted in a up to a zone up to 50 ft. wide of pulverized, crushed and brecciated country rock and vein material. Most veins in this camp show some insignificant post ore faulting. This faulting results in a highly permeable vein, creates poor ground conditions for mining and makes displaced ore bodies difficult to locate. The "A" structure, located on surface and explored by bulldozer stripping is the McLeod vein. The trenching was initiated by encouraging overburden drill results, which located a low- grade silver [3-4 oz./ton] resource. The Hector-Calumet 4-23 North drift intersected the 50 ft wide McLeod vein in the immediate footwall of the Calumet fault.

3.2.4.3 Oxide Zone

Boyle [5] reports that the ore bodies are oxidized down to the 500 level – up to 850 ft. below surface. He also states that ore reserves as of February 1957 were 61,399 tons averaging 36.1 oz./ton silver, 8% lead and 8% zinc. Theses reserves were done near end of production by Mackeno Mines and may represent unoxidized ore remaining in the orebodies located between the 300 and 500 levels. A. Aho [6] reported that in late 1952 ore reserves totalled 48,000 tons averaging 35.5 oz./ton silver, 11.6% lead and 2.2% zinc. This reserve most likely represents ore from the ore bodies between the 300 level and surface around the McLeod shaft. This ore is within 250 ft of surface. The above figure shows the silver and lead content about the same as the 1957 reserves, however the 1952 reserves have a much lower zinc content – 2.2% versus 8%. This could be explained by ore bodies at depth having a higher zinc content, a feature that is sometimes seen in other ore bodies in this camp. A more likely cause is that oxidation has removed 75% of the zinc. The McLeod vein is a highly permeable structure and would promote the movement of ground water down it. The base of the oxide zone is probably a wide transitional zone and is thought to lie between the two orebodies – about 400 ft. below surface.

3.2.4.4 Faults

The McLeod workings are cut by four faults called – 'A', 'B', 'C' and 'D'. A fifth fault called 'E' is postulated to occur between the McLeod workings and Hector-Calumet 4-23 North drift workings where the McLeod vein was intersected in the immediate footwall of the Calumet fault. Fault 'E' may be two or more faults rather than a single fault. All faults have a horizontal right hand displacement of the vein , strike about west-northwest and dip to the southwest. Fault 'A', seen in the Sime workings, cuts the McLeod vein on the 900 level. Fault 'B', a bedding plane fault that cuts the McLeod vein on most levels, is also seen in the 300 level development to the Hector-Calumet 775 level raise connection. Horizontal displacement of the McLeod vein by the 'B' fault ranges from a high of about 150 ft in three faults to a low of 30 ft horizontal displacement on a single fault. Projecting this fault to the 900 level would have it passing through the south end of the McLeod vein workings and crossing the adit where a major water flow was intersected. The many faults mapped in a 300 ft wide zone paralleling the fault suggest that water was not confined to a single fault plane but flowing along many of the faults and fractures in this wide zone. The fault zone should come to surface on the 900 level about 900 ft north of the adit portal. The writer together with Dr. Nand Davé of CANMET in Ottawa visited the 900 portal site in October 14 and 15, 2001. About 10L/sec water was passing through a culvert on the access road near the Elsa – Keno City Road. Following the water back to its source was difficult because of glaciering but its source appears to be the 'B' fault. Fault 'C', a bedding plane fault, was intersected on the 100 level where it has a horizontal displacement of about 75 ft. and again on the 300 level where it has a horizontal displacement of 50 ft. Fault 'C' is plotted as intersecting and joining the steeper 'D' cross fault. The 'D' cross fault dips about 43° and was intersected in the McLeod workings on the 100 and 300 levels where it is two faults about 45 ft apart with a maximum horizontal displacement of about 30 ft. Boyle [3] sampled a spring near the surface trace of the 'D' fault on the road between the Galkeno 300 adit and the Duncan Creek Road. Water from the sample assayed 0.06 ppm in heavy metals [total amount of copper, lead and zinc]. The source of the spring is likely water from the 'D' fault. This fault on the 900 level would daylight about 2300 ft south of the 900 adit portal. If the fault is permeable at lower elevations it may be discharging ground water into Christal Lake unless it has been sealed by permafrost.

Fault 'E' has a 150 ft. horizontal displacement, which correlates the McLeod vein in the Galkeno Mine with the McLeod vein intersected in the Hector-Calumet Mine 4-23 N drift. Fault 'E' may be two or more faults rather than a single fault. A fault with this amount of displacement has the potential to be permeable for the movement of ground water from the McLeod vein to the Christal Lake drainage. Geological information on this fault is sparse and the interpretation may be incorrect.

3.2.4.5 Mine Water

300 Level Adit

Up until two years ago water flows from the adit during the summer months were very low [estimated at < 0.5 L/sec.]. Flows were higher than this in the late spring for a short time when the melting of the snow pack was at the highest. The source for the adit water is surface water and snow melt in the Sime and 35 open pits. The water then moves down the veins and is captured by the 300 level workings and then flows to the adit portal.

Starting about two years ago flows of about 20 L/sec. and containing up to 300 ppm zinc have continued from late spring until well into the early winter. The water flows from the adit portal, across and down the waste rock dump, and then runs down the power line for about 500 ft. where it disappears into the ground. Water is reported as reappearing on surface lower down the hill. The unusually high zinc levels in this water suggest that for the past two years water has started and continues to flush out oxidation products from a new area in either the Sime, 35 or McLeod veins. The source is not likely to be the Hector-Calumet Mine or the McLeod vein because this water eventually discharges at the 900 level where zinc levels have remained about the same over the past two years.

Figure 1 shows a low standard [4 X 4] road running the whole length of the McLeod vein and other roads leading to the edge of the Sime 6 open pit and to the waste rock pile immediately south of the Sime 4 open pit.

These roads after a few years of use end up as shallow depressions and subsequently channel water from the late spring snow melt and the summer rain run off. Water flowing along the roads may end up entering the mine workings. The roads contain above average amounts of water normally in the late spring when snow melt is at a peak. Higher than normal snow melt combined with an unusually wet summer the past two years has resulted in the low standard roads likely having water flow from late spring to freeze up. Another possibility is that run off water initially flowing along the ditch of the Galkeno 300 adit – Calumet Town site road makes it into the Sime or 35 open pits. If water from these roads is entering the McLeod vein workings, part or all of it should end eventually end up on the 900 level. However zinc levels there have remained about the same in the past two years, which suggests that above normal amounts of water, has not been entering the McLeod vein workings.

Water running down the roads to the Sime open pits would directly or indirectly lead to the Sime vein. Production results from the Sime and 35 open pits show that the zinc content of the ore is low and production was from the oxide zone. The writer believes that surface water is entering and passing down the Sime and/or 35 oxide zone where it flushes out the zinc oxidation products. The zinc rich water eventually enters the underground workings and discharges at the 300 level adit portal.

900 Level

Water discharged at the portal comes mainly from the fractures within 150 ft. of the curtain grouted cement plug. At the adit portal, water flows averaging about 10 L/sec is treated and then piped to the settling ponds. Fault 'B' is a conduit that connects the permeable water bearing McLeod vein and discharges water on surface at the break in slope about 900 ft. north of the adit portal. Flows from this are estimated at 10 L/sec. Outside the adit, a spring whose source may be fault 'A', is located just below the pilot wetland treatment cell. Pressure readings taken in 1996 at a pressure gauge in the concrete plug show that the water table is 400 ft. above the adit. At that point directly above the plug the water table intersects the surface of the east facing glacial covered hill. The only place on surface where significant amounts of water issues from this 400 ft. column is where fault 'B' sub crops below the glacial overburden about 900 ft. north of the 900 level adit portal. Away from this fault the bedrock is largely impermeable to water flows as shown by the absence of water until fault 'B' was intersected in the adit. It is believed that any water that makes it to the bedrock- glacial overburden contact flows downhill along this contact only if a thawed window occurs in the permafrost. The water seen weeping out of the bedrock during construction of the settling ponds supports this belief. The glacial material in the area appears to be mainly a silty clay as seen in a nearby ~ 50 ft, vertical exposure in a borrow pit cut into the hillside. This clay rich material would absorb heavy metals in the water. In some cases the clay content may be high enough to stop water flows along the bedrock/glacial material contact from reaching surface.

McLeod Creek

As part of the environmental program by UKHM, three sets of samples were taken in 1994-95 at a site [55] where McLeod Creek discharges into Christal Lake. The samples, which assayed between 0.230 and 0.339 ppm zinc, and averaged 0.29 ppm zinc, are considered anomalous. The writer was personally informed that samples collected at six different times by UKHM of McLeod Creek at the Duncan Creek Road returned only background zinc values. The source of the weak to moderately anomalous zinc in McLeod Creek between the Duncan Creek road and Christal Lake is likely water originating from one or all of faults 'C- D' and 'E'. Water from the Flame and Moth Mine may also be contributing water anomalous in zinc to McLeod Creek.

3.3 Flame and Moth Mine [See Figure 1]

3.3.1 History

The mine is located about 1500 ft south, southeast of Christal Lake. The only ore body found on this vein was explored in 1950 by an inclined shaft and 140 ft of development on the 100 ft. level. UKHM stripped the overburden and started open pit mining the top of the ore body in the late1980s. Some 1590 tons grading 18.31 oz./ton silver, 1.11 % lead and 0.91 % zinc was mined before UKHM permanently shutdown their operation in January, 1989.

3.3.2 Geology

The vein, traced for about 2,000 ft., occurs in a low-lying area largely covered by thick glacial overburden. Where exposed, the vein is a brecciated and sheeted zone up to 20 ft. wide cut by small faults. The mineral content is different from other veins in the camp, and consists mainly of quartz, pyrite, arsenopyrite and sphalerite with minor galena and chalcopyrite. Two mineralized zones on the vein are known; one where the open pit is located and the other one is 800ft. to the northeast. At the mine, the ore body on the 100 ft level is relatively high in zinc and low in lead and silver. Oxidation of the zinc in the upper part of the ore body is strong as shown by comparing the zinc content of the ore from the open pit [0.91%] with the zinc content of the ore body on the 100 ft. level [5%]. The other mineralized zone 800 ft. to the northeast contains mainly pyrite and minor arsenopyrite.

3.3.3 Oxide Zone

Comparing the zinc content [0.91%] from the open pit with the zinc grades [5%] in the ore body on the 100 level indicates that oxidation in the upper part of the ore body is strong. No information is available to the writer as to the base of the oxide zone. Mill bench tests by UKHM on samples from the oxidized ore body gave poor recoveries [~ 65% silver].

3.3.4 Faults

Boyle [5] reports that in outcrop and in the mine underground workings the vein is cut by small faults. The Galkeno Mine faults 'A', 'C-D' and fault 'E' would cut the Flame and Moth vein.

3.3.5 Mine Water

Pyrite and arsenopyrite in this vein would promote the oxidation of the metallic vein minerals. Zinc anomalous ground water flowing from the vein at the Flame and Moth Mine and/or from the other occurrences would be captured by the northwest trending faults and deposited in McLeod Creek between Christal Lake and the Duncan Creek Road.

3.4 Eagle – Rico – Tin Can Occurrences [See Figure 1]

3.4.1 History

Both the Rico and Tin Can occurrences were staked and explored in the 1920s. At the Tin Can the workings consist of trenches, pits and shallow shafts while at the Rico, a shallow shaft and near surface 120 ft adit explored the vein. The Eagle was discovered in the early 1920s and since then explored by hand pits, shallow shafts, bulldozer trenching and in 1964 by diamond drilling. The latest drilling supervised by the writer was in 1978-79 when six holes were drilled.

3.4.2 Geology

These three occurrences are believed to be on a vein or vein system that has an 8,000 ft. strike length with the Eagle on the southwest end, Tin Can on the northeast and the Rico located between them. The Tin Can vein as described by Boyle [5], is 2-5 ft wide and mineralized by small amounts of fresh and oxidized metallic minerals. No ore bodies were found. The Rico is a weak vein with minor pyrite. Galena and sphalerite were not seen in it. The Rico was not seen or recognized in the Galkeno 900 level adit. The Eagle vein consists of a strong main vein and a nearby sub parallel branch vein. The vein, is about 50% exposed over a strike length of 1200 ft, varies from 2 to 16 ft in width, and is mineralized by erratic lenses of galena, tetrahedrite and sphalerite. One of the 1964 drill holes across the vein assayed 4.2% zinc across 6.9ft. A 1978-79 drill hole reported 6.8 % zinc over 5.0 ft. The deepest hole cut the vein about 800 ft. below surface. This vein system, over 8,000 ft. in strike length, is strong at both ends [Eagle and Tin Can] but between them the vein structure appears to be weakly developed.

3.4.3 Oxide Zone

Oxidation in the Eagle trenches is weak and absent in the veins cut by the 1978-79 drilling. Permafrost was not seen or recognized in the 1978-79 Eagle drill holes. Oxidation at the other two occurrences is weak.

3.4.4 Faults

Projecting the Hector and Calumet faults, using known attitudes found at the Hector-Calumet Mine shows both to be a short distance to the southwest and to the northeast respectively of the Eagle occurrence. Geological mapping by UKHM and the Geological Survey of Canada has not recognized these faults in this area. The faults 'A', 'B', 'C' and 'D' seen underground in the Galkeno Mine and the inferred fault 'E' would cut the vein northeast of Hinton Creek.

3.4.5 Surface Water

The bulldozer trench on the Eagle occurrence has surface water estimated at 1-2 L/sec. flowing in at the southwest end and then along the vein. Both McLeod and Hinton Creeks flow year round though at a reduced rate in the winter months when extensive glaciering takes place. The intensity of oxidation is low on the Eagle vein indicating low permeability in and along the vein, therefore the principle source for water in these creeks is mainly the Calumet fault and a lesser amount may come from the Hector fault. Below the road linking the Galkeno 300 adit and the Duncan Creek Road the McLeod Creek disappears into the ground and then reappears in the valley as a spring beside the Duncan Creek Road. It flows along the edge of the road a short distance before it turns and heads for the south end of Christal Lake. Water samples taken on the McLeod and Hinton Creeks by Boyle [4] were not anomalous in heavy metals [total amount of copper, lead and zinc]. The writer is unaware of any recent water sampling on these two creeks. The writer has been told that in the past water samples taken from the spring beside the Duncan Creek Road are anomalous in zinc [~ 4 ppm], however recent sampling of it by UKHM on six occasions returned only background zinc values.

3.5 Mackeno Mill Occurrence [See Figure 1]

3.5.1 Geology

The only information on this is by Boyle [5] who describes a small vein containing siderite outcropping a few hundred feet southeast of the old Mackeno Mill site. It can only be traced a few feet and the extensions are covered by overburden.

3.6 Viola Occurrence [See Figure 1]

3.6.1 Geology

The Viola is a weak vein that has been investigated by an adit that is now caved. Vein material on the dump consists of oxidized siderite and some galena. The vein was not seen or recognized in the Galkeno 900 level adit. It may represent a vein that has split off the Eagle-Rico-Tin Can vein. Boyle reports that complex faulting to the northeast makes it difficult to trace the vein in that direction. These faults could possibly correlate with faults 'A', 'B' and 'C' seen underground at the Galkeno Mine.

4.0 RECOMMENDATIONS

A high priority should be given to locate the source of water flowing out of the Galkeno 300 level adit. The source may be surface run-off making its way along the low standard roads and into the Galkeno mine workings. The mine surface workings and roads should be examined when water flows from the snow pack melt start in mid to late May.

At the Hector-Calumet Mine, the bog below the 400 level adit has removed the zinc in the mine discharge water. The bog should be investigated to determine where the zinc has been captured and if it will continue to remain stable under present conditions.

All known streams and springs and those found by ground traversing the Christal Lake basin should be sampled on a regular basis to satisfy government regulators that background zinc values in groundwater for this area is between 0.25 and 0.30 ppm zinc. This may be important if wetland treatment ponds are established to treat water from the Galkeno 900 level adit.

5.0 REFERENCES

1. Boyle, R.W., Illsley, C.T., and Green, R. N., 1955: A Geochemical Investigation of the Heavy Metal Content of the Streams in the Keno Hill-Galena Hill Area, Yukon Territory; *Geol. Surv. Can.*, Paper 54-18

2. Boyle, R.W., Illsley, C.T., and Green, R.N., 1955: Geochemical Investigation of the Heavy Metal Content of Stream and Spring Waters in the Keno Hill-Galena Hill Area, Yukon Territory; *Geol. Surv. Can.*, Bull. 32

3. Boyle, R.W., Pekar, E.L., and Patterson, P.R., 1956: Geochemical Investigation of Heavy Metal Content of Streams and Spring in the Galena Hill- Mount Haldane Area, Yukon Territory; *Geol. Surv. Can.*, Bull. 36

4. Boyle, R.W., 1957: The Geology and Geochemistry of the Silver-Lead-Zinc Deposits of Galena Hill, Yukon Territory; *Geol. Surv. Can.*, Paper 57-1

5. Boyle, R.W., 1965: Geology, Geochemistry and Origin of the Lead-Zinc-Silver Deposits of the Keno Hill-Galena Hill Area, Yukon Territory: *Geol. Surv. Can.*, Bull. 111

6. Aho, Aro, 1980s: "History Keno Hill Silver Deposits," Unedited manuscript

7. United Keno Hill Mines Limited, 1996: Site Characteristic Report No. UKH/96/01, Prepared by Access Mining Consultants Ltd., June, 1996

Insert Figure 1

FIGURE 1

PLAN VEINS & FAULTS NORTH EAST GALENA HILL-CHRISTAL LAKE AREA

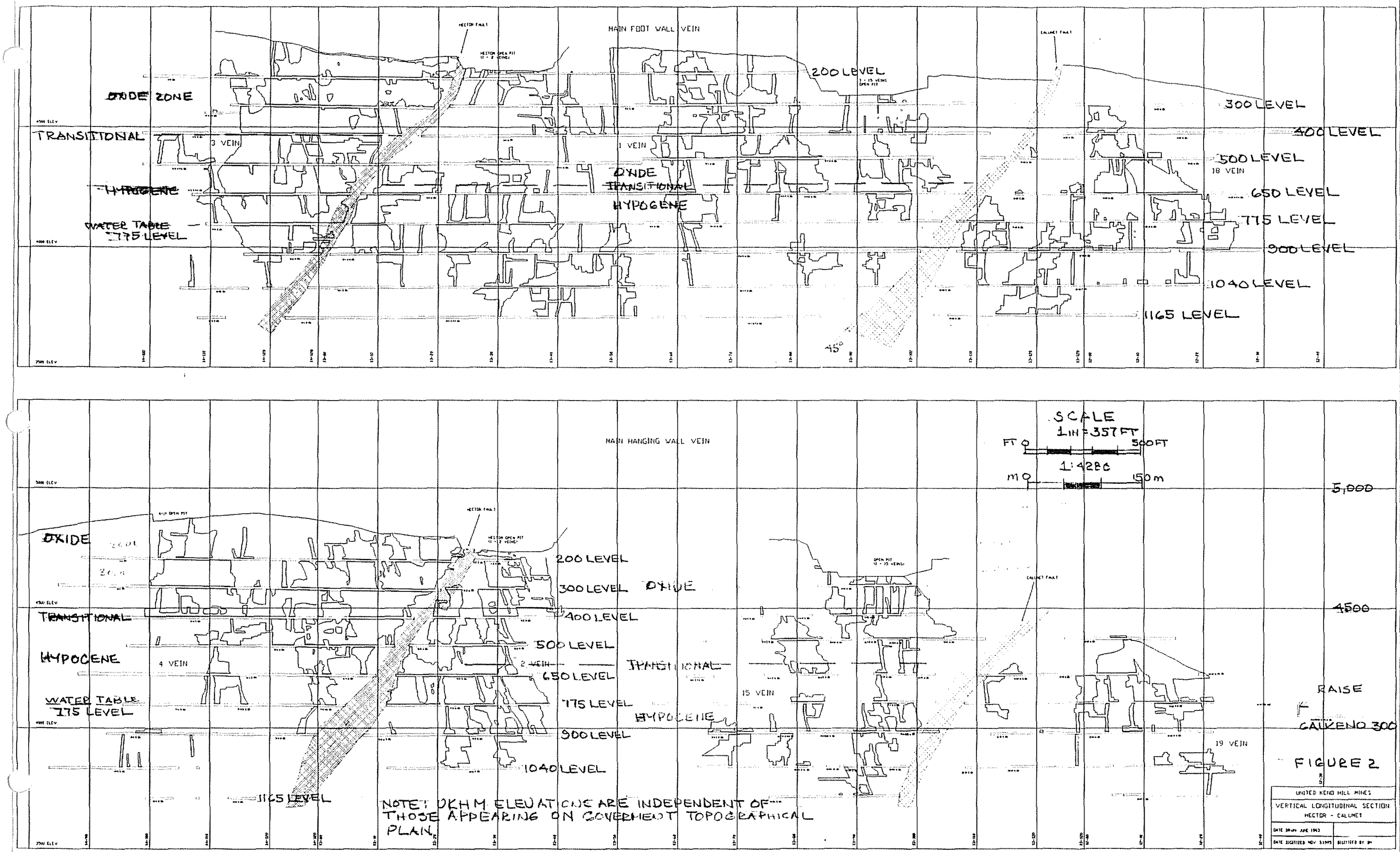
SCALE
1:5,000
m 0 100 200 m
1 in = 417 ft
ft. 0 200 400 600 ft.

LEGEND

- FAULT - SURFACE TRACE & DIP
- VEIN - SURFACE TRACE
- SILVER OCCURRENCE
- LOW STANDARD (4x4) ROAD
- WATER SAMPLE SITE
- MINE WATER

BASE PLAN - FROM NTS 1:50,000 GOVERNMENT TOPOGRAPHICAL PLAN [105 M 14]
NOTE - UKHM ELEVATIONS ARE INDEPENDENT OF THOSE APPEARING ON THE GOVERNMENT TOPOGRAPHICAL PLAN

Insert Figure 2



MAIN FOOT WALL VEIN
HECTOR FAULT
HECTOR OPEN PIT
CALUMET FAULT
OXIDE ZONE
TRANSITIONAL
HYPOGENE
WATER TABLE
775 LEVEL
3 VEIN
1 VEIN
OXIDE
TRANSITIONAL
HYPOGENE
18 VEIN
200 LEVEL
300 LEVEL
400 LEVEL
500 LEVEL
650 LEVEL
775 LEVEL
900 LEVEL
1040 LEVEL
1165 LEVEL
45°
MAIN HANGING WALL VEIN
SCALE
1 IN = 357 FT
FT 0
500 FT
1:4280
m 0
150 m
5,000
4500
OXIDE
TRANSITIONAL
HYPOGENE
4 VEIN
2 VEIN
15 VEIN
19 VEIN
OPEN PIT
WATER TABLE
775 LEVEL
200 LEVEL
300 LEVEL
OXIDE
400 LEVEL
500 LEVEL
TRANSITIONAL
650 LEVEL
775 LEVEL
HYPOGENE
900 LEVEL
1040 LEVEL
1165 LEVEL
RAISE
CALKENO 300
FIGURE 2
NOTE: UKHM ELEVATIONS ARE INDEPENDENT OF THOSE APPEARING ON GOVERNMENT TOPOGRAPHICAL PLAN.
UNITED KENO HILL MINES
VERTICAL LONGITUDINAL SECTION
HECTOR - CALUMET

Insert Figure 3

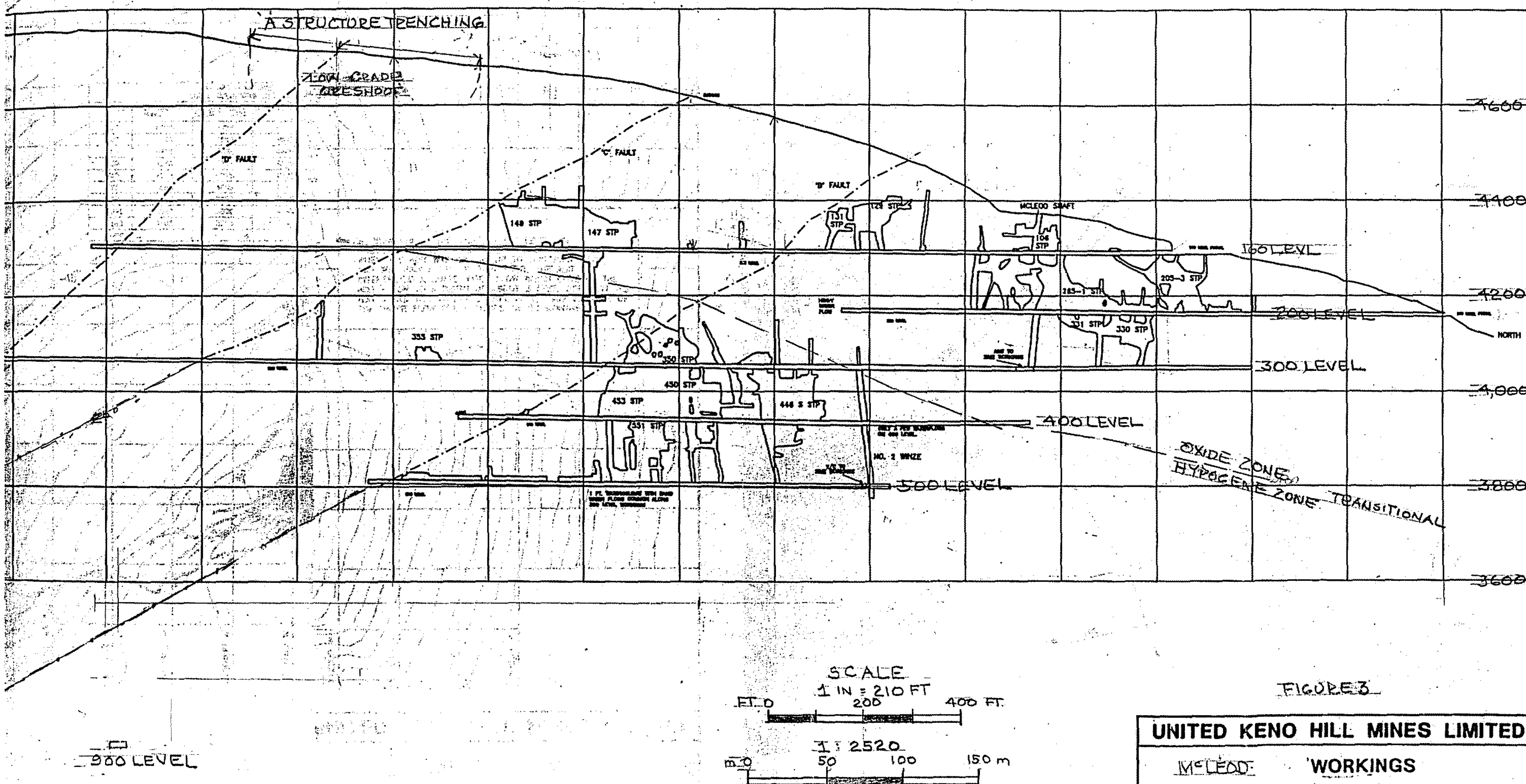


FIGURE 3

NOTE: UKHM ELEVATIONS ARE INDEPENDENT OF THOSE APPEARING ON GOVERNMENT TOPOGRAPHICAL PLANS.

UNITED KENO HILL MINES LIMITED		
McLEOD WORKINGS GALKENO MINE VERTICAL LONGITUDINAL SECTION (Looking West)		
ACCESS MINING CONSULTANTS LTD.		
	FILE: GLONGSEC.DWG	DATE: 28/05/96
PLOTTED:	DWG: 95UK60	FIGURE: 5-26

Insert Figure 4

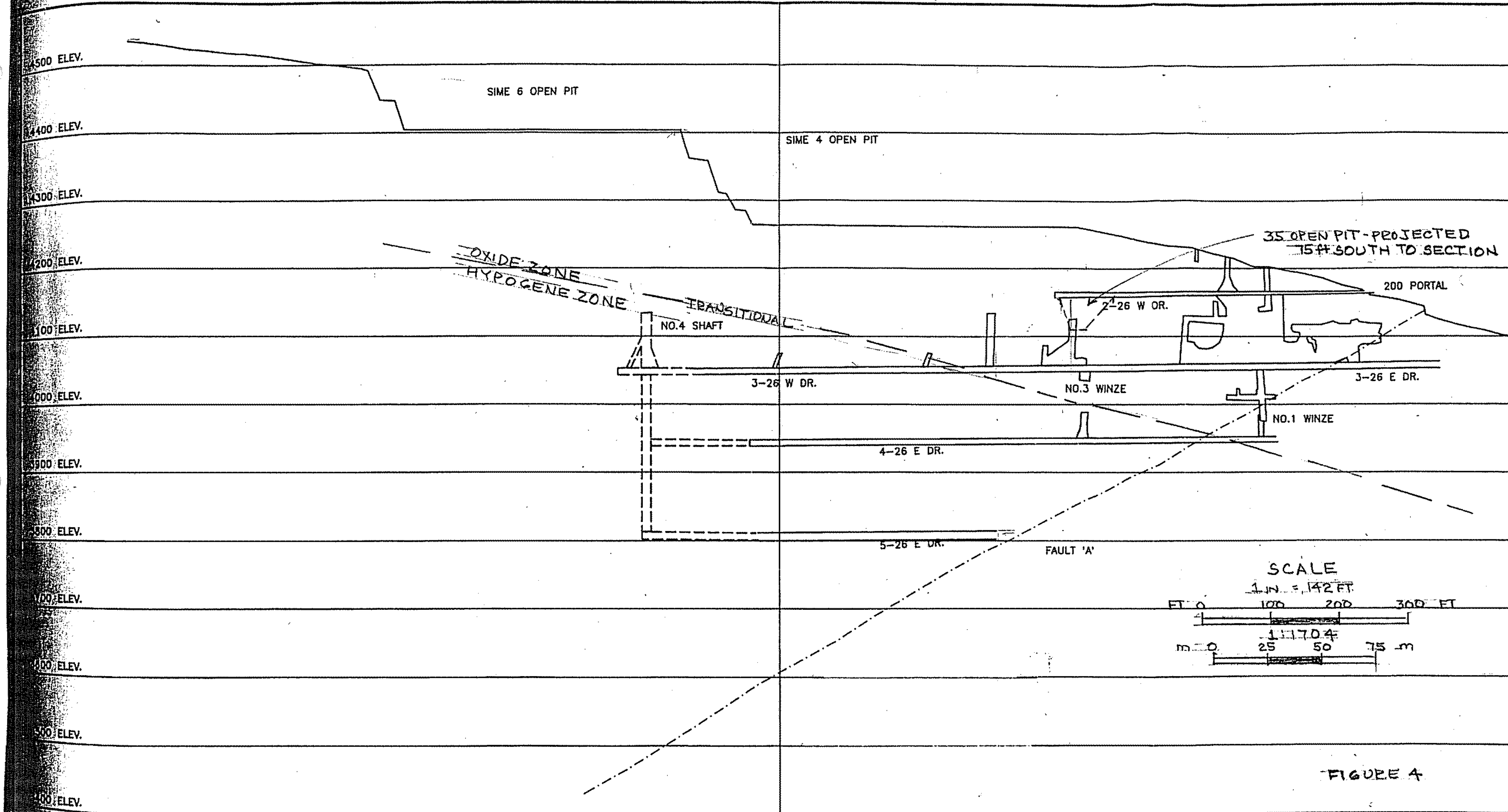


FIGURE 4

NOTE: UKHM ELEVATIONS ARE INDEPENDENT OF THOSE APPEARING ON TOPOGRAPHICAL PLAN

UNITED KENO HILL MINES LIMITED

SIME WORKINGS

GALKENO MINE

VERTICAL LONGITUDINAL SECTION (Looking Azimuth 330°)

ACCESS MINING CONSULTANTS LTD.

	FILE: GALVERT.DWG	DATE: 28/05/96
PLOTTED:	DWG: 95UK34	FIGURE: 5-25

Insert Figure 5

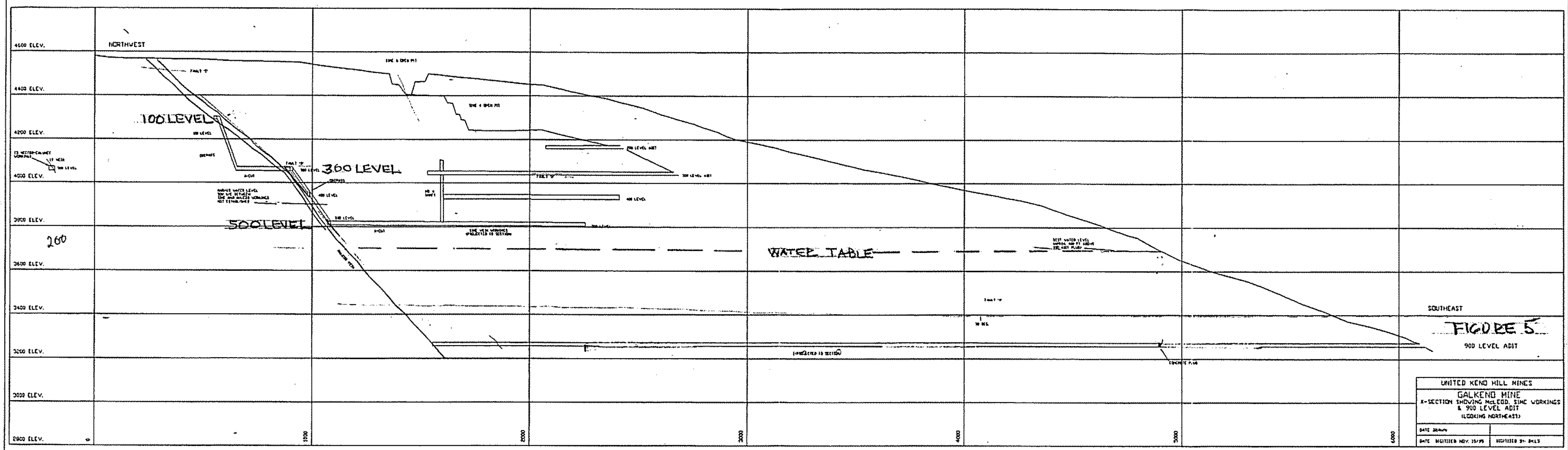


FIGURE 5

NOTE UKHM ELEVATIONS ARE INDEPENDENT OF THOSE APPEARING ON GOVERMENT TOPOGRAPHICAL PLAN

SCALE
1 IN = 444 FT
FT 0 200 400 600 800 FT
1:5,333
m 0 50 100 200 m