Geology, mineralization and sampling results from the Kalzas tungsten property, central Yukon

Gerald G. Carlson
Copper Ridge Explorations Inc.[1]

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ABSTRACT

Kalzas, in central Yukon, is a porphyry-style stockwork and sheeted-vein wolframite deposit. Alteration includes a potassic core, a quartz-tourmaline-sericite zone and an outer quartz-sericite-pyrite zone, the latter in excess of 2 km in diameter. Wolframite is confined to the inner two zones, in an oval area 1500 m by 800 m. The wolframite is disseminated within the quartz-tourmaline stockwork and also occurs as coarse crystals in sheeted veins. Mineralization occurs within Neoproterozoic to Early Cambrian Hyland Group quartzites and phyllites, which are likely intruded at depth by a pluton, possibly of the Cretaceous Tombstone Suite.

From 1981 to 1984, Union Carbide carried out mapping, soil and rock geochemistry, an airborne magnetometer survey, road building, trenching and drilling of two diamond drill holes. Results from Copper Ridge's 2001 sample program range from 0.3% WO_3 to 0.5% WO_3 over widths up to 70 m. They demonstrate the potential to define a significant resource of surface-mineable tungsten mineralization at a grade of 0.4% WO_3 or better. Drilling is required to confirm grade continuity at depth and along strike.

RÉSUMÉ

Le gisement Kalzas, dans la partie centrale du Yukon, est un stockwerk de type porphyrique constitué de filons feuilletés de wolframite. L'altération comprend un noyau potassique, une zone de quartz-tourmaline-séricite et une zone externe de quartz-séricite-pyrite qui mesure plus de 2 km de diamètre. Seules les deux zones internes renferment de la wolframite, dans une région ovale de 1500 m sur 800 m. La wolframite est disséminée dans le stockwerk de quartz-tourmaline; on en trouve également sous forme de cristaux grossiers dans les filons feuilletés. La minéralisation se trouve dans des quartzites et des phyllades du Groupe de Hyland datant du Néoprotérozoïque au Cambrien précoce, sans doute pénétrés en profondeur par un pluton qui pourrait faire partie de la Suite de Tombstone (Crétacé).

Entre 1981 et 1984, la société Union Carbide a dressé des cartes, fait des analyses géochimiques du sol et de la roche, effectué un levé aéromagnétique, construit des routes, creusé des tranchées et exécuté deux forages au diamant. Les résultats obtenus en 2001 dans le cadre du programme d'échantillonnage de Copper Ridge indiquent de 0,3 % à 0,5 % de WO_3 sur des largeurs atteignant 70 mètres. Ces résultats démontrent qu'il est possible de délimiter une importante minéralisation en tungstène qui est exploitable depuis la surface et présente une teneur en WO_3 de 0,4 % ou plus. Il est nécessaire de forer pour s'assurer que la teneur est la même en profondeur et dans l'axe de la minéralisation.

[1]*500-625 Howe St., Vancouver, British Columbia, Canada V6C 2T6; gcarlson@copper-ridge.com*

INTRODUCTION

Kalzas is a world class tungsten deposit consisting of wolframite mineralization in sheeted veins and stockwork. Similar deposits are known particularly in China, Bolivia and Portugal. Kalzas is located south of the Stewart River, 70 km southeast of Mayo (Fig. 1) and 290 km north of Whitehorse. The claims are located in the Mayo Mining District on NTS sheet 105M/7, centred at 63°16'N, and 134°42'W, and are described in Yukon MINFILE (2001, 105M 066). Access is by helicopter from Mayo. A serviceable airstrip exists on the property, accommodating up to a Twin Otter aircraft. Union Carbide developed a 75 km winter road from Mayo in 1983, but it is impossible to discern in many places. The main showing areas of the property are easily reached from the intact bulldozer trails, and these extend to the former campsite and airstrip (1350 m elevation). Most of these are on the north and western flank of the western Kalzas Twin (1936 m elevation). Big Kalzas Lake, 4 km to the south, has an elevation of 780 m. Most of the property is alpine and covered by talus, with some grass and moss on stable slopes. Outcrop is limited to ridge crests and less commonly near the base of talus slopes. Sparse bush and alpine spruce occur below 1400 m. All of the key mineralization discovered to date is above tree line.

The Kalzas property lies within the Selwyn tungsten belt (Cathro, 1969), one of the world's largest tungsten districts (Fig. 1). The belt includes Mactung (32 Mt at 0.92% WO_3 reserves – Dawson, 1995), one of the top three of the world's known tungsten deposits, and Cantung (9 Mt at 1.42% WO_3 production plus reserves – Dawson, 1995), Canada's largest historical tungsten producer. Numerous other known deposits and showings include skarns such as Ray Gulch, Clea and Lened, and an intrusive-related stockwork W-Mo deposit known as Logtung. Coincidentally, this belt partially overlaps the Tintina gold belt (British Columbia and Yukon Chamber of Mines, 2000). Both the gold and the tungsten appear to be genetically related to the mid-Cretaceous Tombstone Plutonic Suite.

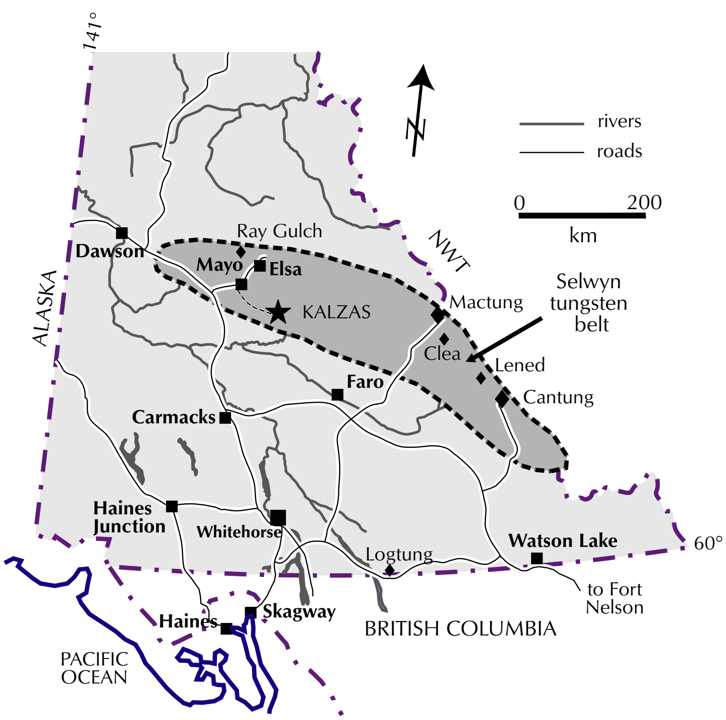

Figure 1. *Kalzas property in central Yukon.*

HISTORY

The property was discovered and staked in 1978 by prospector J.D. Randolph, who was initially investigating high-grade silver showings. In 1980, the property was optioned to Union Carbide Corporation. Union Carbide carried out prospecting, geological mapping, soil sampling, rock and talus sampling and flew an aeromagnetic survey in 1981 and 1982. In 1983, a winter road was constructed from Mayo. Road building and bulldozer trenching exposed outcrop for sampling on the upper slopes of the mountain. An 840-m airstrip was constructed near the camp on the north side of the mountain (Fig. 2). Late in the season, two core drill holes were completed for a total of 668 m.

The initial work by Union Carbide defined a strong (+1000 ppm) tungsten anomaly in soils and talus fines (Fig. 2). The anomaly trends northwest and measures 1500 m long by 300 m to 900 m wide (Fig. 2), and is surrounded and partially overlapped by anomalous values of silver and tin. Sampling of the talus material was carried out in detail on some of the grid lines with 20 kg bulk samples along 20-m and 25-m intervals. On line 43N, a 150-m length averaged 1.04% WO_3 in the quartz vein material and 0.21% WO_3 in country rock. On line 40N, a 175-m interval averaged 0.32% WO_3 (including both quartz veins and country rock).

Union Carbide's work showed the potential for in excess of 100 million tonnes of low-grade (0.1% to 0.2% WO_3) tungsten. Re-sampling by Copper Ridge Explorations Inc. in 2001 confirmed higher-grade zones with widths up to 70 m and grades in the 0.3% to plus 0.5% WO_3 range, and suggested the earlier Union Carbide analyses had understated the tungsten grade.

The property geology was described in internal reports to Union Carbide by Forster in 1981 and 1984. Lynch (1985a,b, 1989) described the mineralization and alteration, and Roots (1997) mapped the bedrock at 1:250 000 scale.

GEOLOGY AND MINERALIZATION

REGIONAL GEOLOGY

The Kalzas property is underlain by the Yusezyu Formation belonging to the Neoproterozoic to Early Cambrian Hyland Group. It consists of metasandstone with grit, quartzite and phyllite, a distinctive black slate member, and minor limestone and conglomerate. Regionally, these rocks form the basal unit of the Selwyn Basin, deposited on the continental margin of ancient North America. These sedimentary rocks were subsequently deformed between Upper Jurassic and Lower Cretaceous time and intruded by mid-Cretaceous 'S'-type granitic rocks.

In the Kalzas region, deformation consisted of imbricate faulting, folding and transposition on slaty cleavage. The layering in most outcrops is tectonic, rather than depositional, and few primary bedding features are preserved (Roots, 1997).

The nearest exposed intrusions are granite, located about 10 km north of the Kalzas property. Kalzas is slightly south of a southeasterly trend of small plugs spaced about 40 km apart between Scheelite Dome (Mair et al., 2000) and the Russell Range. These are part of the 90 Ma to 95 Ma Tombstone Plutonic Suite and many have associated gold and/or tungsten mineralization. A buried intrusion likely underlies the property, as suggested by a large concentrically zoned alteration halo at Kalzas (Lynch, 1985a,b) combined with a complex, annular aeromagnetic anomaly. However, no granitic rocks have been found in outcrop at Kalzas.

GEOLOGY OF THE KALZAS PROPERTY

Unaltered host rock at Kalzas consists of interbedded chloritic phyllite and feldspathic quartzite, with lesser amounts of siltstone, dark shale and quartz-feldspar pebble conglomerate. The phyllite is composed of chlorite, sericite and quartz and commonly grades into siltstone. It sometimes displays rusty weathering due to minor pyrite content.

The quartzite consists of 80% to 90% quartz as coarse sand-sized grains, with the remainder of the rock consisting of feldspar with trace zircon and magnetite. Individual quartzite layers are up to 3 m thick and contacts with phyllite are typically sharp. There are at least two conglomerate layers within the wolframite zone, with rounded quartz clasts and up to 10% feldspar clasts. Bedding strikes northwesterly and has steep to vertical dips. Tight folding has been observed, and bedding attitudes suggest a property-scale southeasterly plunging antiform.

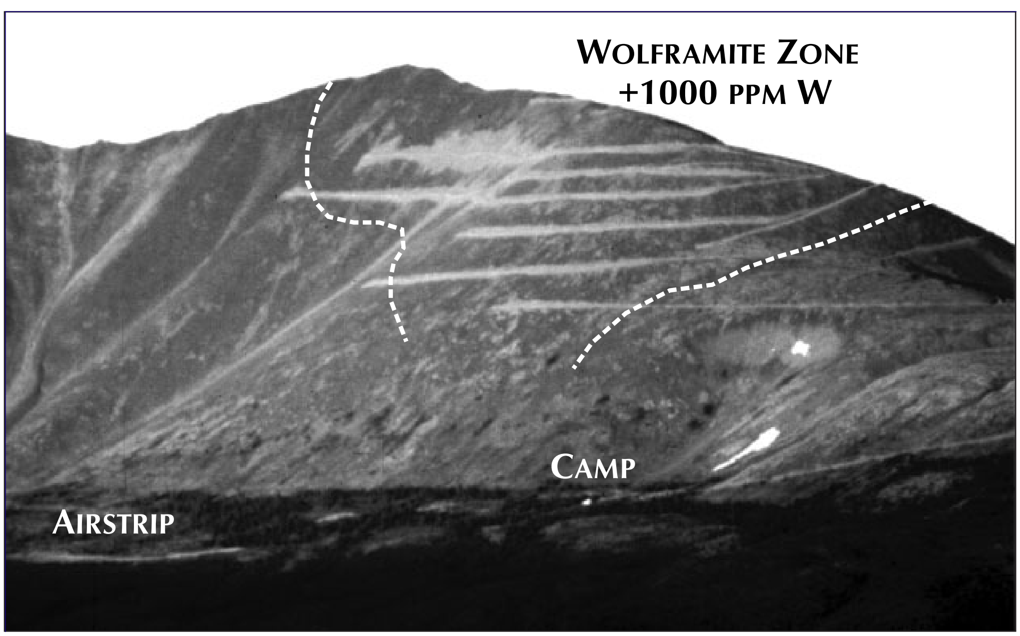

Figure 2. *Southeast view of the tungsten zone on west Kalzas Twin (photo by C. Roots).*

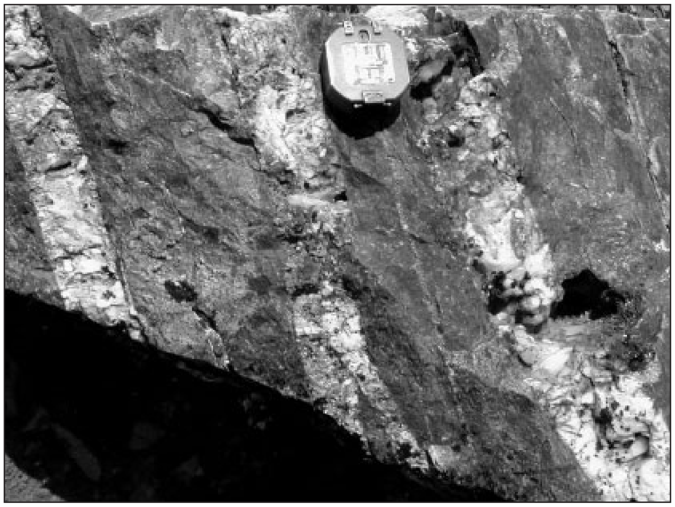

Figure 3. *Vuggy sheeted veins, containing bladed wolframite crystals, cutting tourmalinized quartzite.*

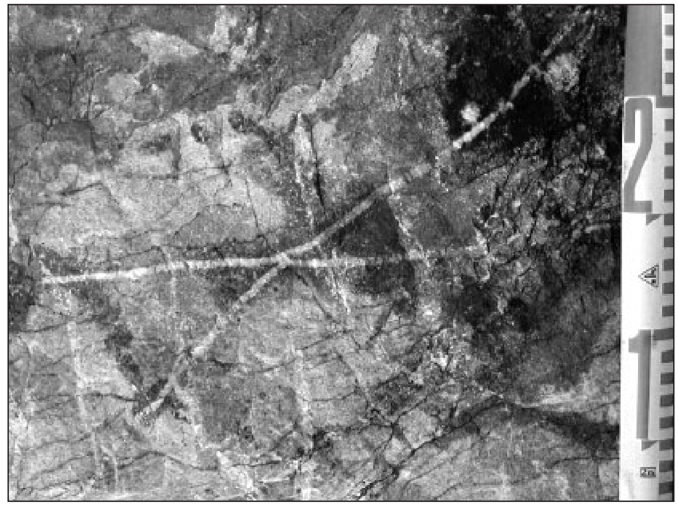

Figure 4. *Quartz stockwork with tourmalinization (dark patches) along selvage and along fractures. The sericitized-quartzite host rock is pale in colour. Scale divisions are in centimetres.*

SHEETED VEINS AND STOCKWORK

Mineralization and alteration at Kalzas are related to a broad zone of sheeted veins and stockwork that comprise an oval, northwesterly elongated, porphyry style hydrothermal system. Sheeted veins (Fig. 3) range from 5 cm to as much as 60 cm thick, averaging about 20 cm. They are typically tabular, occur in sets and have been traced up to 50 m along strike. Although the larger sheeted veins have a variety of orientations, most strike approximately 070° and dip 35° to the northwest, roughly perpendicular to the southeast plunging fold axis.

Stockwork veinlets typically range from 0.1 to 1 cm thick, forming a complex boxwork. The veinlets are vuggy and contain euhedral to subhedral quartz, wolframite and tourmaline, with a complete gradation from pure tourmaline to pure quartz. Lynch (1985a,b) recognized up to six different ages of veinlets. Open fractures that appear to be younger than the stockwork mineralization are typically dark rusty-weathering and are commonly coated with a black, glassy, limonitic stain. Some fractures are lined with cassiterite crystals.

ALTERATION

Three roughly concentric alteration phases form a northwest-trending oval, approximately 2.5 km long. The core is a K-feldspar zone, followed by a quartz-tourmaline-sericite zone and the outermost quartz-sericite-pyrite zone (Lynch, 1985a,b).

The quartz-sericite-pyrite zone has a distinct whitish colour with rusty patches due to pyrite weathering. Weak and relatively minor stockwork and sheeted veins occur in this zone, whereas sericitization is pervasive. There is typically less than 5% disseminated pyrite, as 1-2 mm cubes.

The quartz-tourmaline-sericite zone is characterized by tourmaline in sheeted veins, stockwork, vein halos, and as pervasive alteration of the host rocks. Halos to these veinlets typically consist of several millimetres of tourmaline, grading to sericite. Where stockwork is less intense, the rock tends to be pervasively altered, with sericite dominating in the quartzitic units and tourmaline in the phyllite (Fig. 4).

The core zone is characterized by K-feldspar and minor sulphide minerals in sheeted veins, and biotite in the wallrock. Biotite occurs preferentially in the quartzite, replacing chlorite. Biotite also occurs in sinuous micro-veinlets. Sulphide minerals include pyrite, pyrrhotite, chalcopyrite, molybdenite, bismuthinite, galena and arsenopyrite. Other accessory minerals include apatite and rutile.

MINERALIZATION

Tungsten mineralization at Kalzas consists mainly of wolframite, with up to 10% of the tungsten values occurring as scheelite, in sheeted veins and stockwork. The zone of tungsten mineralization overlaps the core potassic zone and most of the quartz-tourmaline-sericite zone.

Wolframite occurs as coarse-grained bladed crystals up to 20 cm long within the sheeted veins and quartz stockwork. It is also disseminated within the quartz-tourmaline-altered host rock (Fig. 4). Scheelite occurs as encrustations on wolframite and sometimes as large, euhedral crystals in quartz veins. Tin occurs as cassiterite in tabular crystals and amorphous masses irregularly on fracture surfaces around the periphery of the wolframite zone.

Higher-grade sections occur in areas dominated by quartzite and conglomerate units. Phyllitic bands may be present in higher-grade sections. Generally, the greater the proportion of phyllite, the lower the tungsten grade. Many of the fractures and stockwork zones that appear to correlate with the higher-grade mineralized zones are sub-parallel to the bedding direction. Bedding throughout the mineralized zone is typically steeply dipping and strikes northwest, parallel to the long axis of the mineralized system (Fig. 5).

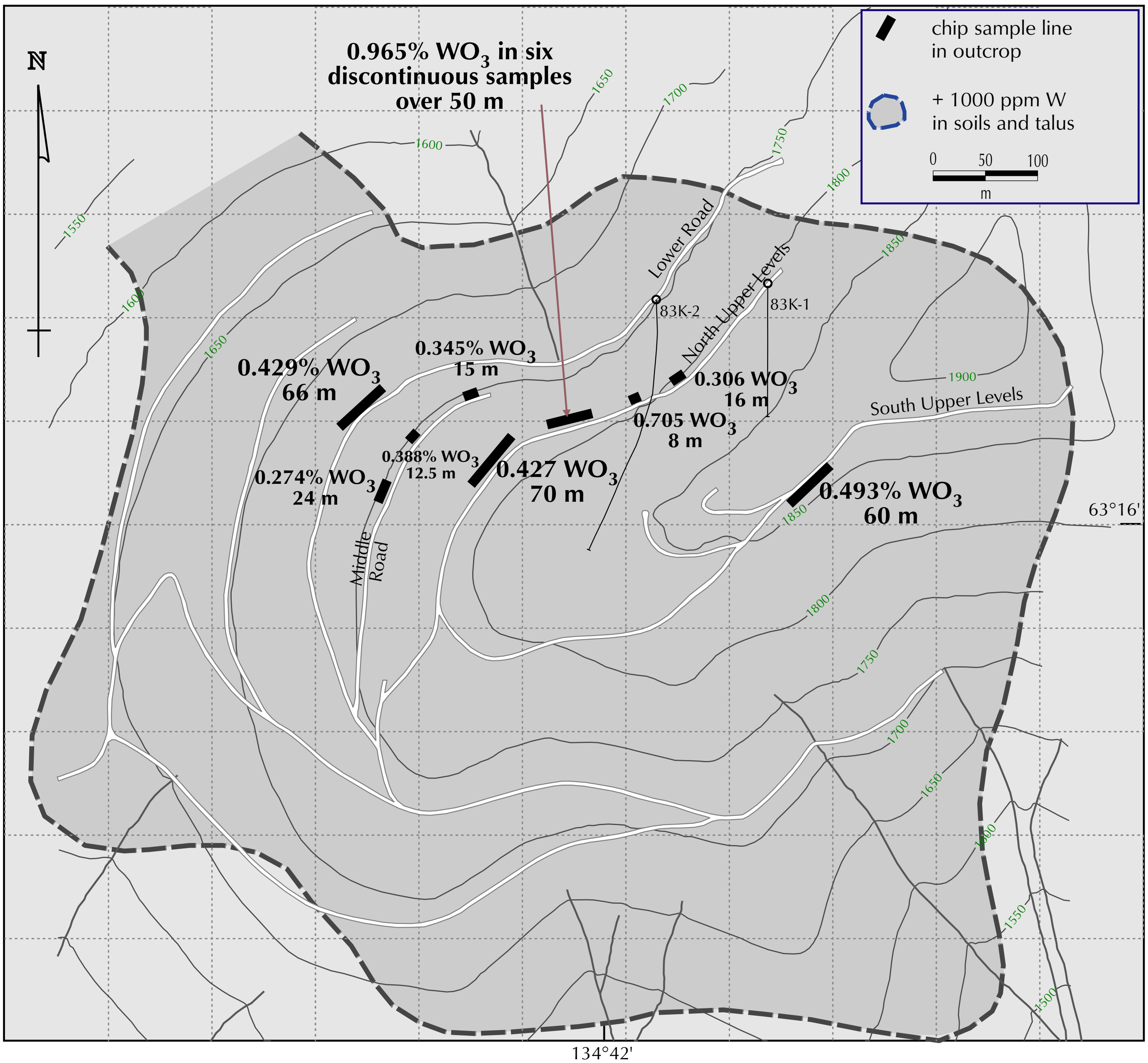

Figure 5. Location sketch showing results of tungsten chip samples in trenches at the Kalzas property.

The structural control of mineralization is probably related to the regional structures that controlled emplacement of the underlying pluton. In addition to the dominant northwest-, and regional east- and northeast-trending structures, interpretation of Union Carbide's airborne magnetics survey indicates a local radial fracture pattern that was noted by C. Forster (pers. comm., 1984) and could be related to intrusion of the pluton.

It appears from the structural observations noted above and the pattern of higher-grade tungsten zones in bedrock as shown in Figure 5, that the west-northwest orientation (305°), roughly parallel to the fold axis and to bedding, is important in controlling these high-grade zones.

2001 ACTIVITY

After acquiring an option on the Kalzas property, Copper Ridge completed a one-week program of resampling core and trenches in August, 2001.

ANALYTICAL METHODS

Table 1 shows analytical results from this study. Initially, the 127 trench samples were analysed at Acme Analytical Laboratories for whole rock trace elements by inductively coupled plasma-mass spectometry (ICP-MS) using a lithium borate fusion. Subsequently, 22 samples were sent to Activation Laboratories, Inc. for confirmation of tantalum analysis using neutron activation ('INAA'). Both the tantalum and the tungsten concentrations by INAA were lower than those by ICP-MS; the tungsten averaged 20% lower than the original whole rock results.

Subsequently, 29 samples of mostly higher-grade tungsten intervals were selected for assay at Acme. The assay values averaged approximately 7% higher than the equivalent whole rock analysis, with considerable variability, particularly for low to medium tungsten values. A further check on these samples by assay at Bondar Clegg gave results that confirmed the Acme assays, typically within a few percent.

RESULTS

The results from the Copper Ridge trench sampling show a significant increase in tungsten values over those reported by Union Carbide. However, exact comparisons cannot be made because the locations of Union Carbide samples are not precisely known, and individual assay results are not available. Table 2 shows averages from the Copper Ridge sampling over the higher grade sections.

Table 1. *Comparison of whole-rock geochemistry and assays by Acme and Bondar Clegg.*

Sample Number	Acme Whole Rock W%	Acme Assay W%	Bondar Clegg Assay W%
C 115009	0.84	0.73	0.73
C 115010	0.77	0.61	0.60
C 115011	0.27	0.21	0.21
C 115012	0.12	0.09	0.10
C 115013	0.83	0.91	0.83
C 115014	1.46	1.52	1.38
C 115025	0.11	0.09	0.10
C 115026	0.99	0.89	1.06
C 115027	0.11	0.09	0.10
C 115028	0.91	1.04	0.96
C 115029	0.10	0.06	0.09
C 115030	0.02	0.01	0.02
C 115031	0.06	0.06	0.06
C 115032	0.16	0.14	0.15
C 115033	0.05	0.05	0.06
C 115046	1.79	2.06	1.99
C 115083	3.47	4.10	4.23
C 115142	0.19	0.22	0.20
C 115143	0.71	0.80	0.92
C 115144	0.45	0.37	0.44
C 115145	0.09	0.07	0.09
C 115146	0.10	0.10	0.10
C 115147	1.46	1.72	1.78
C 115148	0.11	0.10	0.10
C 115149	0.07	0.07	0.07
C 115150	1.24	1.49	1.53
C 115153	0.18	0.20	0.18
C 115154	0.03	0.03	0.03
C 115155	0.19	0.22	0.19
Averages	**0.58**	**0.62**	**0.63**

Table 2. *Tungsten geochemistry (by ICP-MS) of trenched areas on west Kalzas Twin (see Figure 5 for location).*

Trench	Width (m)	Grade (% WO_3)
South Upper Road	60	0.493%
North Upper Road (east end)	16	0.306%
North Upper Road (middle)	8	0.705%
North Upper Road (west end)	70	0.427%
North Middle Road	20	0.268%
North Lower Road	64	0.442%

Results from individual samples within these intervals are listed in Appendix A.

Some of the highest results come from the middle of the North Upper Road in an area of discontinuous outcrop of intense stockwork mineralization within a quartzite unit. Here, 26.5 m of sampled outcrop within the 50-m interval along the road averaged 0.965% WO_3.

A strongly mineralized zone along the South Upper Road averages 0.493% WO_3 over 60 m. Characteristic of this section, and most of the other trench intervals that assayed high tungsten values, the host rock is sericitized quartzite ranging from pale grey to greenish yellow with a dark brown, rusty weathering on many of the exposed outcrop surfaces. This section contains few larger or sheeted veins. Most of the tungsten appears to be related to stockwork veins and possibly also to disseminated or fracture-controlled mineralization.

COPPER RIDGE VS. UNION CARBIDE TRENCH ASSAY RESULTS

Although exact comparisons cannot be made because of lack of detailed descriptions of the Union Carbide sampling program, Copper Ridge results are on the order of 30% to over 50% higher than those of Union Carbide. In his 1984 internal company report, Forster described the on-site analytical procedure. Samples were crushed to –1/4 in., split, pulverized to –100 mesh, and analysed on an Asoma 8010 XRF field analyser in camp to determine the percent WO_3. Forster noted that laboratory checks done by Bondar-Clegg in Whitehorse tended to be lower for results less than 0.35% WO_3 but 30% higher than the field XRF results for higher values.

Potential errors could be introduced at a number of stages in this field analytical procedure. During sample preparation, particularly during sample splitting, tungsten could be lost to the final sample because of the high density of the tungsten minerals (wolframite and scheelite). Field portable XRF technology was crude in 1983, and results were not as reliable as could be achieved in a laboratory. For example, because of low power output, the unit would have scanned only the surface of any powdered sample, rather than the entire sample (B. Smee, pers. comm., 2001). Even lab results of that era, probably using an acid digestion followed by atomic absorption, might have understated tungsten values had the digestion of the sample not been complete or had the instrument flame not been hot enough.

Most of the Copper Ridge sampling was on the north and western slope of the western Kalzas Twin peak. The sheeted veins typically dip to the northwest at 30° to 35°. As a result, very few sheeted veins outcrop on this slope. The majority of the mineralization sampled by Copper Ridge appeared to be stockwork or disseminated in nature, with relatively little visible wolframite. Sample to sample results from the Copper Ridge sampling program do show variability (see Appendix A), but not the extreme fluctuations that would be expected if a nugget effect was significantly influencing the results.

DISCUSSION

Union Carbide's exploration program showed the size potential of Kalzas to be in the hundreds of millions of tonnes, or a smaller tonnage at higher grades. However, the estimation of average grade proved to be a difficult issue for Union Carbide because of the perceived nugget effect created by the coarse wolframite mineralization in the sheeted veins. In contrast, the evaluation by Copper Ridge described here suggests that the grade estimation problem may have related more to sample handling procedures and analytical technique.

Average grades reported by Union Carbide are in the range of 0.2% WO_3 to 0.3% WO_3, typically over widths of 50 m to 75 m. It appears that the Union Carbide work was focused on defining a resource of greater than 100 million tonnes.

Sampling by Copper Ridge during the current program was directed at confirming the tungsten values and assessing the potential for commercial tantalum mineralization. No tantalum minerals were identified and subsequent analysis both by wet chemical methods and by neutron activation failed to detect economic values of tantalum. Typical tantalum values at Kalzas are in the range of 1-2 ppm, with a high of 8.7 ppm.

Copper Ridge's tungsten sampling, however, demonstrated a significant increase over the Union Carbide results. The Copper Ridge averages are in the range of 0.3% WO_3 to 0.5% WO_3 over widths up to 70 m. The results of the Copper Ridge sampling suggest that the nugget effect issue may not be so great a concern. Very little of the Copper Ridge sampling was actually in sheeted veins, but more in stockwork and disseminated mineralization. The results of this sampling are reasonably consistent from one sample to the next, with less variability than would be expected with a nugget effect problem.

The Copper Ridge results are based on chip channel samples averaging 5 m in length over exposures limited by the Union Carbide trenching. No firm conclusions can be drawn regarding actual grades, widths and continuity of zones without further detailed sampling, including both large diameter core drilling and bulk samples.

ECONOMIC POTENTIAL

Union Carbide identified the broad, sheeted vein and stockwork tungsten complex over 1000 m in length and over 500 m in width. The potential within this zone is to develop a deposit in the hundreds of millions of tonnes of mineralization. Sampling suggests the grade of such a deposit could be in excess of 0.1% WO_3. In terms of size, this would rank Kalzas as one of the top three or four tungsten deposits in the world.

The sampling and evaluation by Copper Ridge indicates the possibility of defining a resource on the order of several tens of millions of tonnes of surface-mineable tungsten mineralization at a grade of 0.4% WO_3 or better. This mineralization occurs in higher-grade zones on the order of 50 m wide, in excess of 500 m in length and trending west-northwest, parallel to the bedding and the main structural grain of the deposit. Drilling will be required to demonstrate grade continuity within these higher-grade zones both at depth and along strike from sampled surface exposures.

A preliminary economic analysis carried out by Copper Ridge suggests that open pit mining at a rate of 5000 tonnes per day on a resource of 20 to 30 million tonnes grading about 0.5% WO_3 has the potential to provide an attractive rate of return. However, because of the very large size of the Kalzas mineralized system and the grade variability within it, both higher and lower throughputs will be examined based upon future exploration work and pre-feasibility studies.

ACKNOWLEDGEMENTS

Many of the geological descriptions in this paper are based on a solid base of fieldwork during the period 1981 to 1984 by Union Carbide Corporation, under the direction of Charlie Forster, and M.Sc. thesis fieldwork by Greg Lynch at Washington State University. The current sampling program was carried out by Aurum Geological Consultants under the able guidance of Al Doherty. Yukon Geology Program geologists Craig Hart and Mike Burke visited the project during the sampling program and provided useful discussion and ideas. Diane Emond and Charlie Roots provided helpful and constructive reviews of the paper.

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APPENDIX A. SUMMARY OF TUNGSTEN VALUES (BY ICP-MS), TRENCH RESULTS

Kalzas Project: Tungsten values and averages, chip channel and core samples, August 1-6, 2001.

	Sample	Abbreviated UTM coordinates		Width		Averages	
Location	No.	East	North	(m)	WO_3 (%)	Width (m)	WO_3 (%)
Upper Levels	115001	4951	5130	5.0	0.379	16.0	0.306
Upper Levels	115002	4946	5128	5.0	0.345		
Upper Levels	115003	4944	5124	6.0	0.214		
Upper Levels	115005	4922	5107	4.0	0.312	8.0	0.705
Upper Levels	115006	4916	5107	4.0	1.097		
Upper Levels	115009	4874	5095	8.0	1.053	26.5	0.965
Upper Levels	115010	4856	5099	2.8	0.971		
Upper Levels	115011	4850	5088	2.8	0.347	26.5 m of discontinuous	
Upper Levels	115012	4850	5085	4.0	0.155	outcrop exposure over	
Upper Levels	115013	4846	5081	4.5	1.050	approximately 50 m	
Upper Levels	115014	4837	5079	4.4	1.847		
Upper Levels	115025	4786	5060	5.0	0.139	70.0	0.427
Upper Levels	115026	4781	5056	10.0	1.247		
Upper Levels	115027	4772	5050	10.0	0.143		
Upper Levels	115028	4767	5040	10.0	1.147		
Upper Levels	115029	4762	5036	5.0	0.123		
Upper Levels	115030	4757	5032	5.0	0.027		
Upper Levels	115031	4753	5027	5.0	0.076		
Upper Levels	115032	4747	5022	10.0	0.198		
Upper Levels	115033	4740	5013	10.0	0.068		
Middle Road	115044	4753	5115	5.0	0.059	15.0	0.345
Middle Road	115045	4750	5114	3.0	0.011	20.0	0.268
Middle Road	115046	4747	5114	2.0	2.261		
Middle Road	115047	4741	5114	5.0	0.065		
Middle Road	115049	4704	5082	5.0	0.140	12.5	0.388
Middle Road	115050	4699	5071	5.0	0.794		
Middle Road	115051	4699	5067	2.5	0.074		
Middle Road	115058	4681	5027	5.0	0.183	24.0	0.274
Middle Road	115059	4681	5028	5.0	0.886		
Middle Road	115060	4683	5013	5.0	0.034		
Middle Road	115061	4683	5001	5.0	0.077		
Middle Road	115062	4682	5008	4.0	0.172		
Middle Road	115063	4673	5005	5.0	0.135	11.0	0.178
Middle Road	115064	4673	5000	3.0	0.396		
Middle Road	115065	4673	4999	3.0	0.032		
South Slope	115075	5085	5052	4.3	0.221	7.3	0.164
South Slope	115076			3.0	0.082		
Lower Road	115080	4698	5151	10.0	0.109	66.0	0.429
Lower Road	115081	4689	5146	10.0	0.047		
Lower Road	115082	4682	5135	5.0	0.007		
Lower Road	115083	4679	5128	5.0	4.375	41.0	0.652

APPENDIX A. (continued)

Location	Sample No.	Abbreviated UTM coordinates East	North	Width (m)	WO_3 (%)	Averages Width (m)	WO_3 (%)
Lower Road	115084	4674	5124	5.0	0.101		
Lower Road	115085	4670	5119	5.0	0.150		
Lower Road	115086	4664	5123	3.0	0.025		
Lower Road	115087	4664	5118	4.5	0.153		
Lower Road	115088	4657	5119	5.0	0.127		
Lower Road	115089	4653	5109	5.0	0.289		
Lower Road	115090	4649	5108	4.5	0.085		
Lower Road	115091	4650	5104	2.0	0.179		
South U. Levels	115142	5039	5023	5.0	0.238	60.0	0.493
South U. Levels	115143	5045	5024	5.0	0.891		
South U. Levels	115144	5047	5029	5.0	0.563		
South U. Levels	115145	5050	5033	5.0	0.119		
South U. Levels	115146	5054	5033	5.0	0.127		
South U. Levels	115147	5056	5039	5.0	1.836		
South U. Levels	115148	5059	5044	5.0	0.143		
South U. Levels	115149	5064	5046	5.0	0.094		
South U. Levels	115150	5068	5052	5.0	1.566		
South U. Levels	115175	5069	5055	5.0	0.205		
South U. Levels	115176	5074	5057	5.0	0.070		
South U. Levels	115177	5078	5062	5.0	0.067		