Biogeochemical Orientation Survey Data from NTS 93F/2 and 7 (Davidson-Blackwater): Outer bark of lodgepole pine

Colin Dunn and Vic Levson

Abstract

Results from the analyses of the outer bark of lodgepole pine (*Pinus contorta*) collected at 51 sites in the Interior Plateau region of central British Columbia are presented. The biogeochemical samples were collected on the Tsacha Lake (NTS 93 F/2) and Chedakuz Creek (NTS 93 F/7) 1:50:000 scale mapsheets. The concentrations of 44 elements in the ash of the bark samples are presented. The mean concentrations of most elements, including lead, zinc, copper, silver, nickel, gold, arsenic and antimony, are higher than in a larger regional survey conducted just to the northwest (on NTS mapsheets 93F/12, 13, 14). Likewise the maximum concentrations of most elements, including gold, arsenic, silver, nickel and zinc, are higher than in the survey to the northwest. In particular, mean and maximum concentrations of gold (40 ppb and 733 ppb, respectively) are an order of magnitude higher. The three highest concentrations of gold (733, 408 and 109 ppb) are clustered in one area southwest of Top Lake. Concentrations of the pathfinder element arsenic are also elevated at these sites (10-12 ppm; >75th percentile). The anomalously high gold concentrations, clustering of the three sites, and high associated arsenic concentrations, suggest that there is an undiscovered gold occurrence in this area. An additional area of interest, with the fourth highest gold occurrence in the study area (74 ppb), occurs in the Big Bend Creek area. Two nearby sites have elevated gold (18-25 ppb) and one of these shows more than 90th percentile arsenic (15 ppm) and antimony (2.6 ppm). No mineral occurrences have been recorded in this area or at a number of other identified locations with high metal concentrations.

Introduction

Samples of outer bark from lodgepole pine (*Pinus contorta*) were collected at 51 sample stations on an opportunistic basis while conducting a till geochemical survey as part of the British Columbia Geological Survey's Interior Plateau Geoscience Project in 1994 (O'Brien *et al.,* 1995: Levson and Giles, 1997). The study area included the Tsacha Lake (NTS 93 F/2) and Chedakuz Creek (NTS 93 F/7) 1:50,000 scale mapsheets. The bedrock geology of the study area was mapped by Diakow et al. (1995a, 1995b) and the surficial geology was mapped by Giles and Levson (1995) and Weary et al. (1995). A compilation map of the bedrock and surficial geology of the region (NTS 93 F/2, 3, 6, 7) was provided by Diakow and Levson (1997). The locations and numbers of biogeochemical samples presented in this paper are provided on Figure 1.

Sample collection, preparation and analysis

Each sample comprised approximately 50 g of tissue obtained by scraping, with a hardened steel paint-scraper, the scaly outer bark from the circumference of a single pine tree. The scrapings were placed in a standard 'kraft' soil sample bag and shipped to the laboratories of the Geological Survey of Canada in Ottawa. They were dried, and reduced to ash by controlled ignition at 470^oC. Ash samples (mostly 0.5 g, unless there was insufficient material) were accurately weighed into small polypropylene vials and submitted to Activation Laboratories Ltd. (Ancaster, Ontario) for irradiation and determination of 36 elements by instrumental neutron activation analysis (INAA). For samples with sufficient ash (only 21 of the original 51 samples), a second aliquot was sent to Acme Laboratories Ltd. (Vancouver) for 0.25 g of material to be digested in aqua regia and analyzed by inductively-coupled plasma optical emission spectrometry (ICP-OES). The latter provided data for elements for which the INAA method is not suitable at the concentrations present (e.g., base metals, P, Al, Ti, V and B). The data from these two methods were merged with field observations and are presented in Appendix 1 and in the accompanying Excel workbook. This workbook contains a separate sheet that summarizes all of the control samples – sample preparation duplicates, analytical duplicates, and SRM (standard reference material) samples. These control samples verified that the data quality varied from good to excellent, depending on element concentration levels, and on the analytical method employed.

Results

Summary statistics for a total of 44 elements, analyzed by either ICP-OES or INAA, are presented in Table 1. In order to put the data shown in Table 1 into context with common values found in bark ash from lodgepole pine in central British Columbia, data are presented in Table 2 that show statistics on elements determined (by the same methods) in 268 samples from farther north in the same 1:250,000 map sheet (Ootsa- François Lake area NTS 93F 12/13/14 – Dunn and Hastings, 1998). Of particular note are the higher concentrations in the present dataset of arsenic and gold. Conversely, the Ootsa-François Lake area has much higher concentrations of molybdenum.

Figure 2 illustrates the gold concentrations in the bark ash in the study area. Of note for the present data release is that some gold concentrations in bark ash samples are significantly higher than those from a regional survey conducted in the Ootsa-François Lakes region (see Tables 1 and 2), just to the northwest of this study area (on NTS mapsheets 93F/12, 13, 14). Mean and maximum concentrations of gold (40 ppb and 733 ppb, respectively) in this study are an order of magnitude higher than the mean and maximum (2.9 ppb and 20 ppb, respectively) from the Ootsa-François Lakes survey (Dunn and Hastings, 1998). In addition, the mean concentrations of most other elements, including lead, zinc, copper, silver, nickel, gold, arsenic and antimony, and the maximum concentrations of most elements, including gold, arsenic, silver, nickel and zinc, are higher in this study than in the Ootsa-François Lakes survey (Tables 1 and 2).

The three highest concentrations of gold (733, 408 and 109 ppb) are clustered in one area southwest of Top Lake (Figure 2). Concentrations of the pathfinder element arsenic are also elevated at these sites (10-12 ppm; >75th percentile). Two other sites in the area also have elevated gold (25 and 51 ppb). This area is covered by a thick till blanket and the regional ice flow direction is north-eastward (Giles and Levson, 1995). The only reported mineral occurrence in the area is the Buck showing (MINFILE 093F 050), located five to seven kilometres to the southwest. It is unlikely that the Buck is the source of the gold because of the high concentrations compared with the large transport distance. Also, the Buck is mainly a Ag-Pb-Zn showing with little gold (minerals present include sphalerite, pyrite, pyrrhotite, chalcopyrite and galena). The anomalously high gold concentrations, clustering of the sites, and high associated arsenic concentrations, suggest the presence of an undiscovered gold occurrence in this area.

An additional site of interest (site 4002, Figure 1), with the fourth highest gold occurrence in this study (74 ppb), occurs in the Big Bend Creek area in the northeast part of the study area (Figure 2). Two nearby sites (4001 and 4005) in that area have elevated gold (18 and 25 ppb) and one of these shows more than 90th percentile arsenic (15 ppm) and antimony (2.6 ppm). No mineral occurrences have been recorded in this area suggesting that the area would be worthy of follow-up sampling.

As expected, gold concentrations at several sites (e.g. 2012, 2013, 2017, 2018, 2019, 2022, and 2042) around the Blackwater-Davidson mineral occurrence are elevated (17 to 42 ppb). The second highest copper concentration (236 ppm) in the study area occurs at sites (2025 and 2011) on both the north and south sides of Mt. Davidson. Site 2025 also has high gold (45 ppb), molybdenum (11 ppm), lead (51 ppm) and zinc (4100 ppm). The distribution of these sites in relation to known mineralization should be investigated. Likewise, high gold, silver, zinc and molybdenum and the highest copper (288 ppm) and nickel (107 ppm) occur at sites around the April (Au-Ag-Zn) and C (Cu-Mo) mineral occurrences. However, several other areas with similarly high, or even higher, metal concentrations occur at sites in the region distant from known mineral occurrences. For example, the highest molybdenum (11 ppm) and highest lead (55 ppm) in the study area occur at site 4034. The highest silver (4 ppm) occurs at site 4033 and the second highest zinc (4200 ppm) occurs at site 4038. All these sites are distant from known mineralization.

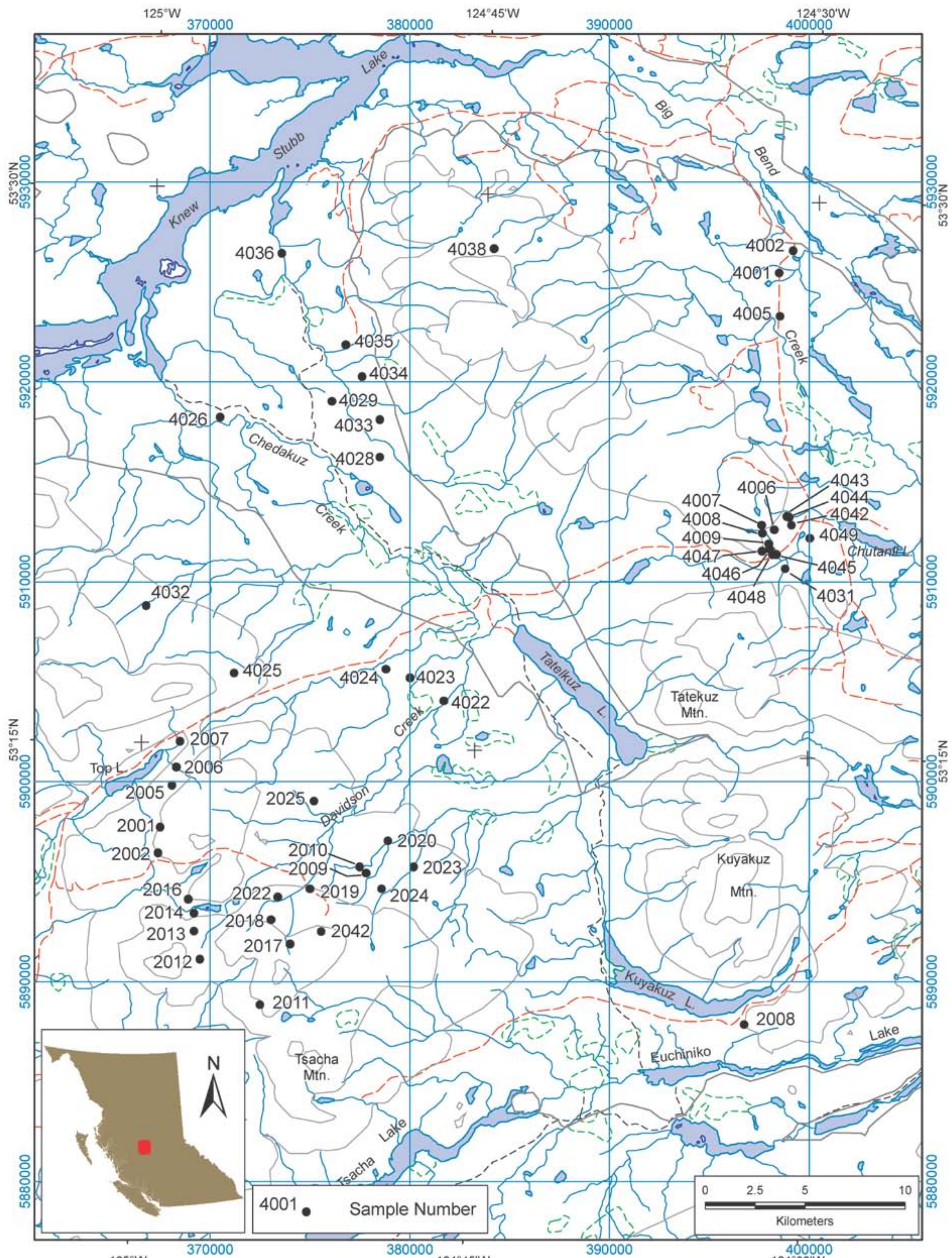

Figure 1: Sample locations and numbers of biogeochemical samples of lodgepole pine bark.

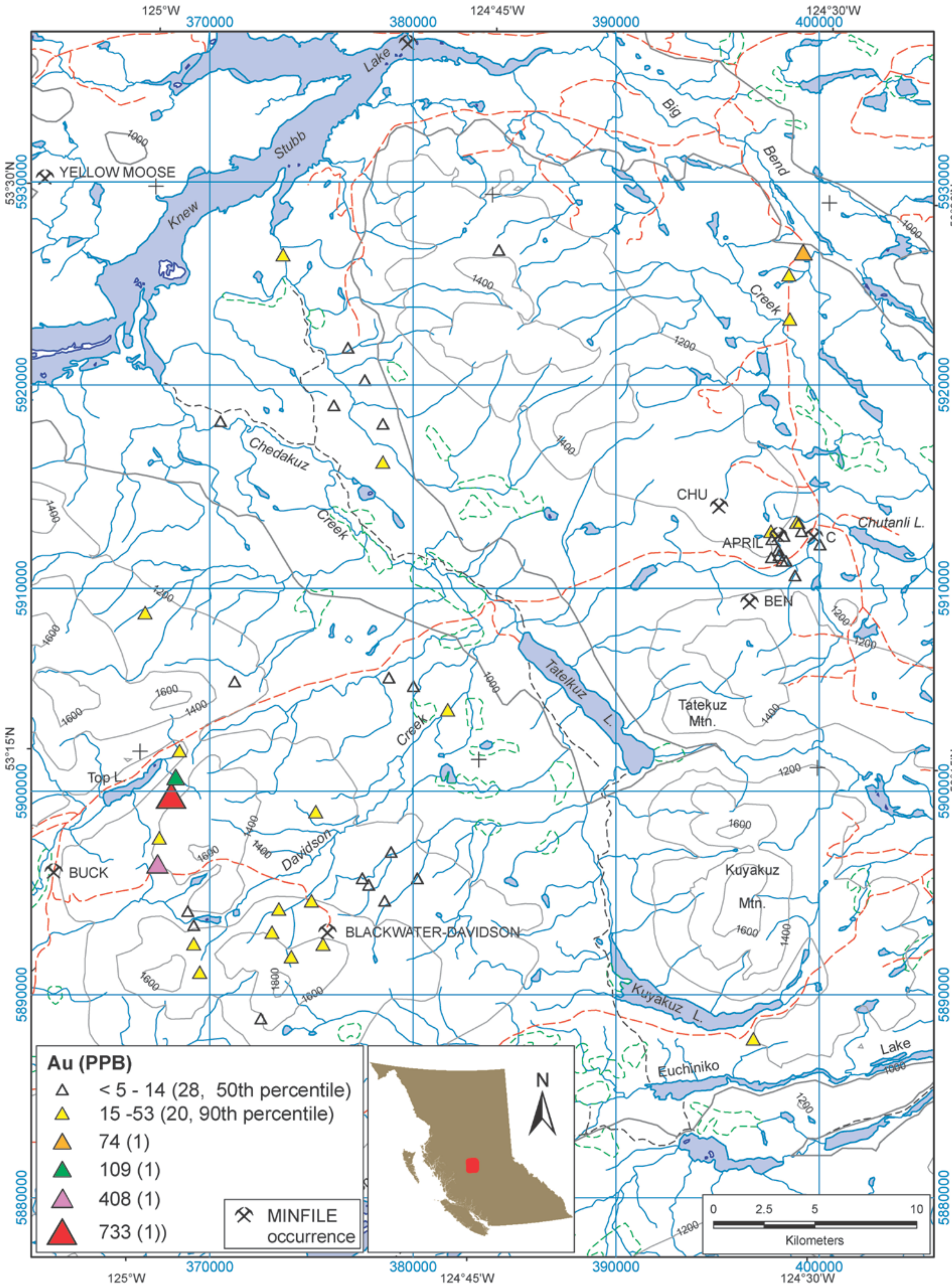

Figure 2: Sample locations with gold concentrations in lodgepole pine bark ash.

	Method	N	Mean	Std. Dev.	Minimum	Percentiles				Maximum
						25	*50*	*75*	*90*	
AG_PPM	INAA	51			-2	-2	-2	-2	3.8	10
Ag_ppm	ICP-OES	21	0.85	0.93	-0.1	0.35	0.6	0.88	2.16	4
AL_PCT	ICP-OES	21	2.1	0.98	0.46	1.4	1.99	2.35	3.88	4.28
AS_PPM	INAA	51	6.8	5	0.9	2.8	5.7	7.9	14	28
AU_PPB	INAA	51	40	115	-5	8	14	21.8	53	733
B_PPM	ICP-OES	21	153	49	25	124	148	192	213	237
BA_PPM	INAA	51	681	377	230	430	570	844	1200	2400
BR_PPM	INAA	51	29	16	9	17	24	31	56	84
CA_PCT	INAA	51	30.1	7.0	6.9	28	31	34	37	40
CD_PPM	ICP-OES	21	22	21	2	7	13	26	61	83
CE_PPM	INAA	51	9	12	-3	4	7	10	20	65
CO_PPM	INAA	51	5.7	2.9	2	3	6	6	9.8	16
CR_PPM	INAA	51	12	14	-1	5	7	12	28	76
CS_PPM	INAA	51	1.8	1.8	-0.5	0.8	1.5	2.14	4.2	7.9
CU_PPM	ICP-OES	21	150	66	56	103	141	200	236	288
EU_PPM	INAA	51	0.19	0.34	-0.05	-0.02	0.12	0.24	0.52	1.74
FE_PCT	INAA	51	0.7	0.77	0.15	0.29	0.52	0.7	1.41	4.39
HF_PPM	INAA	51	0.62	1.3	-0.5	-0.5	0.7	1.14	1.86	6.3
K_PCT	INAA	51	4.2	1.8	1.5	3.01	3.91	5	6.9	8.22
LA_PPM	INAA	51	5.1	5.6	1	2.2	3.5	4.9	9.36	33
LU_PPM	INAA	51		0.14	-0.05	-0.05	0.07	0.1	0.2	0.61
MG_PCT	ICP-OES	21	2.44	0.81	1.1	1.74	2.49	2.97	3.67	3.85
MN_PPM	ICP-OES	21	7455	2861	1891	5573	7794	8268	12464	13446
MO_PPM	INAA	51	1.8	3.7	-2	-2	3	4	6	11
NA_PPM	INAA	51	3904	4092	738	1860	2750	3548	7158	22200
ND_PPM	INAA	51			-5	-5	-5	5.4	10.8	38
NI_PPM	ICP-OES	21	18	24	-1	3	11	18.4	40	107
P_PCT	ICP-OES	21	0.78	0.39	0.24	0.42	0.74	1.03	1.37	1.43
PB_PPM	ICP-OES	21	32	14	7	23	31	40	52	55
RB_PPM	INAA	51	71	53	-5	42	65	80	142	300
SB_PPM	INAA	51	1.0	0.62	0.3	0.7	0.9	1.1	1.66	4.1
SC_PPM	INAA	51	2.3	2.8	0.4	0.9	1.5	2.1	5.02	14
SM_PPM	INAA	51	0.97	1.11	0.2	0.4	0.7	0.9	1.88	5.9
SR_PPM	INAA	51	980	497	-300	770	1100	1200	1480	2000
TA_PPM	INAA	51			-0.5	-0.5	-0.5	-0.5	-0.5	0.8
TB_PPM	INAA	51			-0.5	-0.5	-0.5	-0.5	-0.5	1
TH_PPM	INAA	51	0.73	0.81	-0.1	0.3	0.5	0.8	1.52	4.3
TI_PCT	ICP-OES	21	0.03	0.04	-0.01	0.01	0.02	0.02	0.07	0.17
U_PPM	INAA	51			-0.1	-0.1	-0.1	-0.1	0.88	1.9
V_PPM	ICP-OES	21	12	14	2	4	7	11	27	67
Y_PPM	ICP-OES	21	5	2.4	3	3.5	4	4	7.6	14
YB_PPM	INAA	51	0.55	0.69	-0.05	0.24	0.34	0.51	1.25	3.57
ZN_PPM	INAA	51	2522	975	470	1900	2400	3140	3800	4300
ZR_PPM	ICP-OES	21	5.5	2	3	4	5	6.4	8	11

Table 1: Summary statistics of element concentrations in the ash of outer bark from lodgepole pine (Pinus contorta)

		N	Mean	Std. Dev.	Minimum	Percentiles				Maximum
						25	50	75	90	
AG	ICP-OES	268	0.38	0.72	-0.8	-0.4	0.5	0.8	1.3	4
AL	ICP-OES	268	1.4	0.7	0.14	0.9	1.34	1.76	2.3	3.9
AS_PPM	INAA	268	2.6	2.0	0.25	1.2	1.85	3.3	5.7	11
AU_PPB	INAA	268	2.9	1.6	2.5	2.5	2.5	2.5	5	20
BA_PPM	INAA	268	528	194	150	390	500	648	780	1200
BR_PPM	INAA	268	13	5	5	9	11.5	15	20	31
Ca_%	ICP-OES	268	30.74	7.29	10.3	25.63	30.95	37.1	40	44.5
CD	ICP-OES	268	15	9.0	-1	8.43	12.7	18.6	26	54.6
CE_PPM	INAA	268	11	11	1.5	4	7	16	28	53
CO_PPM	INAA	268	4.7	2.8	1	3	4	5	10	16
CR_PPM	INAA	268	9.3	8.8	0.5	4	6	13	21	56
CS_PPM	INAA	268	1.2	1.9	0.25	0.25	0.8	1.3	1.8	24
CU	ICP-OES	268	104	45	38	74	94	120	162	380
EU_PPM	INAA	268	0.26	0.29	0.01	0.01	0.16	0.38	0.67	1.28
Fe_%	ICP-OES	268	0.64	0.62	0.09	0.22	0.35	0.82	1.57	2.94
HF_PPM	INAA	268	0.91	0.84	0.25	0.25	0.6	1.4	2.3	3.6
K_%	ICP-OES	268	3.53	1.6	1.2	2.44	3.25	4.23	5.4	15
LA_PPM	INAA	268	5	5.1	0.8	1.9	3.3	7.55	13	26
LU_PPM	INAA	268	0.09	0.09	0.03	0.03	0.05	0.13	0.23	0.42
MG	ICP-OES	268	1.36	0.44	0.46	1.09	1.3	1.54	1.9	3.38
MN	ICP-OES	268	6711	3703	992	3757	5893	8732	11968	21570
MO	ICP-OES	268	16	19	-4	6	11.5	22	42	142
MO_PPM	INAA	268	17	13	3	9	14	21.75	32	92
NA_PPM	INAA	268	5050	4597	959	1773	3070	7363	12220	24600
ND_PPM	INAA	268	6.1	5.9	2.5	2.5	2.5	8	15	31
NI	ICP-OES	268	9.3	5.7	-2	6	8	12	16	36
P	ICP-OES	268	5686	2142	2197	4103	5416	6698	8551	14928
PB	ICP-OES	268	16	16	-4	6	12	20	34	120
RB_PPM	INAA	268	38	21	2.5	23.25	35	47	60	180
SB_PPM	INAA	268	0.76	0.79	0.1	0.4	0.6	0.9	1.4	10
SC_PPM	INAA	268	2	2.1	0.3	0.63	1.1	2.58	5.2	11
SM_PPM	INAA	268	1.0	1.0	0.1	0.3	0.6	1.4	2.6	5
SR_PPM	INAA	268	1055	322	150	865	1000	1200	1400	2300
TH_PPM	INAA	268	0.76	0.7	0.05	0.3	0.5	1.1	1.81	3.3
U_PPM	INAA	268	0.27	0.35	0.05	0.05	0.05	0.48	0.81	1.6
V	ICP-OES	268	14	10	2	6	10	18	28	52
YB_PPM	INAA	268	0.53	0.53	0.03	0.17	0.31	0.71	1.43	2.48
ZN_PPM	INAA	268	1872	564	470	1500	1800	2200	2600	3900
Ash%		268	2.2	0.74	0.79	1.72	2.17	2.69	3.06	5.97

Table 2: Summary statistids of element concentrations in the ash of outer bark from lodgepole pine *(Pinus contorta*) - Nechako Plateau (NTS 93F_12/13/14 - Dunn and Hastings, 1998

To further put these gold data into context, a comparison can be made with a survey conducted in the La Ronge Belt of northern Saskatchewan. A small survey was conducted in an area where a gold-rich quartz vein was exposed and its projected extension lay beneath a boggy area underlain by till. Black spruce bark samples were collected along the projected vein strike for 750 m (Dunn, 1986; 1995, 2007). Anomalies were found, and subsequently drilled to reveal mineralized zones as indicated below in Table 3. This location was developed as the Jolu gold mine in the late 1980s.

Gold (ppb) in Black Spruce Bark Ash	Gold (ppb), approx. dry wt. equivalent	Overburden Thickness	Drill Results
230	4.6	1 m	Tree close to outcrop, near main trench.
120	2.4	1 m	1 m of 0.85 oz/ton (~25 ppm) Au at depth of 50 m.
690	13.8	2.5 m	Subcropping mineralization - 0.11 oz (~3 ppm) Au over 60 cm.
450	9	1 m	Subcropping mineralization - 0.3 - 0.7 oz/ton (~10 - 22 ppm) Au over 4 m.
200	4	3 m	Locally over 1 oz/ton (~30 ppm) at shallow depth.

Table 3: Gold in the ash of black spruce outer bark, with subsequent drill hole data for comparison (La Ronge Belt, northern Saskatchewan; Dunn, 1986, 1995, 2007).

Conclusion

Anomalously high gold concentrations found in three lodgepole pine bark ash samples in the Top Lake area suggest that an undiscovered gold occurrence might exist in this area. This conclusion is supported by elevated concentrations of associated pathfinder elements and by data from other nearby sites. The proximity of the three sites with high gold also suggests a related source. An additional area of interest with high gold occurs in the Big Bend Creek area. Significantly high concentrations of other metals occur at numerous sites within the study area that warrant further investigation. Whereas control samples all indicate that the analytical data for the 51 samples in this release are of acceptable quality, it should be noted that three of the samples that yielded the highest gold concentrations were within the first batch of samples that were analyzed by INAA. The three high gold samples were interspersed with lower gold samples and there is no evidence to suggest that their presence in the first batch is anything other than coincidental. However, it is strongly recommended that the data be viewed in context of other geological, geophysical and geochemical data and that additional sampling should be undertaken to verify the reproducibility of these elevated levels before any conclusions are drawn and significant exploration expenditures are made.

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SAMPLE NUMBER	LAB NUMBER	EASTING	NORTHING	DATUM	UTM ZONE	SITE_ID	SPECIES	TISSUE Method:	TILL SAMPLE	Ag_ppm INAA	Ag_ppm ICP-OES	Al_pct ICP-OES	As_ppm INAA	Au_ppb INAA
								Detection limits:		***2***	***0.1***	***0.01***	***0.5***	***5***
2001	AL94/1692	367505	5897717	NAD83	10	2003	LP	BK		<2			7.9	51
2002	AL94/1693	367405	5896417	NAD83	10	2002	LP	BK		<2			12	408
2005	AL94/1696	368105	5899817	NAD83	10	2005	LP	BK		8			12	733
2006	AL94/1697	368305	5900717	NAD83	10	2006	LP	BK		<2			10	109
2007	AL94/1698	368505	5902017	NAD83	10	2007	LP	BK		<2			9	25
2008	AL94/1699	396753	5887840	NAD83	10	2008	LP	BK	1006	<2			14	25
2009	AL94/1700	377504	5895717	NAD83	10	2009	LP	BK		<2			6.4	<5
2010	AL94/1701	377804	5895417	NAD83	10	2010	LP	BK		2			7.3	8
2011	AL94/2061	372504	5888817	NAD83	10	2011	LP	BK		<2	0.7	4.28	3.4	7
2012	AL94/1702	369505	5891117	NAD83	10	2012	LP	BK		<2			17	28
2013	AL94/1703	369205	5892517	NAD83	10	2013	LP	BK		4			7.9	17
2014	AL94/1704	369205	5893417	NAD83	10	2014	LP	BK		<2			2.7	11
2016	AL94/1706	368905	5894117	NAD83	10	2016	LP	BK		<2			2.8	11
2017	AL94/2062	374004	5891867	NAD83	10	2017	LP	BK		<2	1.4	2.39	2	18
2018	AL94/2063	373056	5893070	NAD83	10	2018	LP	BK	1026	<2	0.3	1.69	2.4	32
2019	AL94/1707	375004	5894617	NAD83	10	2019	LP	BK	1029	<2			10	42
2020	AL94/2064	378904	5897017	NAD83	10	2020	LP	BK		2	<0.1	1.59	2	9
2022	AL94/2065	373389	5894217	NAD83	10	2022	LP	BK	1027	<2	0.4	2.42	2.3	17
2023	AL94/2066	380211	5895721	NAD83	10	2023	LP	BK	1035	2			2.7	9
2024	AL94/2067	378604	5894617	NAD83	10	2024	LP	BK		<2	2.3	2.26	2.6	<5
2025	AL94/2059	375204	5899017	NAD83	10	2025	LP	BK	1194	<2	0.8	3.78	3.7	45
2042	AL94/1708	375567	5892481	NAD83	10	2042	LP	BK	1052	8			6.2	21
4001	AL94/1709	398504	5925417	NAD83	10	4004	LP	BK		<2			5.7	25
4002	AL94/1710	399211	5926543	NAD83	10	4002	LP	BK	3009	<2			13	74
4005	AL94/1713	398555	5923273	NAD83	10	4005	LP	BK	3013	<2			15	18
4006	AL94/2068	398254	5912572	NAD83	10	4006	LP	BK	3129	<2	1.4	3.11	2.6	14
4007	AL94/2069	397616	5912803	NAD83	10	4007	LP	BK	3130	<2	0.1	1.42	0.9	19
4008	AL94/2072	397664	5912414	NAD83	10	4008	LP	BK	3131	<2	1.6	1.83	2.4	7
4009	AL94/2073	397985	5911881	NAD83	10	4009	LP	BK	3132	<2	0.5	3.9	4.2	7
4022	AL94/1715	381704	5904017	NAD83	10	4022	LP	BK		3			15	23
4023	AL94/1716	380016	5905181	NAD83	10	4023	LP	BK	3027	<2			7.1	8
4024	AL94/1717	378804	5905617	NAD83	10	4024	LP	BK		<2			7.8	13
4025	AL94/1718	371204	5905417	NAD83	10	4025	LP	BK		10			6.5	12
4026	AL94/1719	370505	5918217	NAD83	10	4026	LP	BK		<2			4	12
4028	AL94/1721	378513	5916217	NAD83	10	4028	LP	BK	3042	<2			9.2	17
4029	AL94/1722	376104	5919017	NAD83	10	4029	LP	BK		<2			7.2	14
4031	AL94/1724	398804	5910617	NAD83	10	4031	LP	BK		<2			7.2	<5
4032	AL94/1725	366805	5908817	NAD83	10	4032	LP	BK		<2			8	32
4033	AL94/2074	378504	5918106	NAD83	10	4033	LP	BK	3084	4	4	0.46	1.6	<5
4034	AL94/2081	377612	5920265	NAD83	10	4034	LP	BK	3088	<2	0.4	2.27	4.6	<5
4035	AL94/2075	376795	5921843	NAD83	10	4035	LP	BK	3094	<2	0.7	1.18	3.9	8
4036	AL94/2076	373604	5926417	NAD83	10	4036	LP	BK		<2			4.2	53
4038	AL94/2077	384222	5926641	NAD83	10	4038	LP	BK	3072	<2			3.3	13
4042	AL94/2078	399130	5912815	NAD83	10	4042	LP	BK	3115	<2			6.9	10
4043	AL94/2079	398888	5913260	NAD83	10	4043	LP	BK	3117	<2	0.7	2	5.3	18
4044	AL94/2080	399004	5913217	NAD83	10	4044	LP	BK		<2	0.5	1.37	3.7	7
4045	AL94/2082	398361	5911356	NAD83	10	4045	LP	BK	3126	<2	0.3	2.32	28	14
4046	AL94/2085	398019	5911623	NAD83	10	4046	LP	BK	3147	<2	<0.1	1.18	1.4	<5
4047	AL94/2086	397654	5911517	NAD83	10	4047	LP	BK		<2	0.6	1.99	4.7	<5
4048	AL94/2087	398175	5911351	NAD83	10	4048	LP	BK	3148	<2	0.4	1.87	10	7
4049	AL94/2088	400039	5912147	NAD83	10	4049	LP	BK	3149	<2	1	1.1	4.3	11

SAMPLE NUMBER	LAB NUMBER	B_ppm ICP-OES	Ba_ppm INAA	Br_ppm INAA	Ca_pct INAA	Cd_ppm ICP-OES	Ce_ppm INAA	Co_ppm INAA	Cr_ppm INAA	Cs_ppm INAA	Cu_ppm ICP-OES	Eu_ppm INAA	Fe_pct INAA	Hf_ppm INAA	K_pct INAA
		2	*10*	*1*	*0.2*	*0.2*	*3*	*1*	*1*	*0.5*	*1*	*variable*	*0.05*	*0.5*	*0.05*
2001	AL94/1692		450	32	33.4		6	4	6	2		0.25	0.42	<0.5	4.05
2002	AL94/1693		520	22	35.3		<3	3	6	0.9		<0.03	0.35	0.5	4.75
2005	AL94/1696		390	17	28		10	3	9	2		<0.04	0.55	<0.5	7.85
2006	AL94/1697		550	30	27.6		7	6	8	<0.5		<0.05	0.6	<0.5	6.63
2007	AL94/1698		300	27	33.9		4	3	5	1.5		<0.02	0.22	<0.5	4.34
2008	AL94/1699		460	29	34.2		4	4	7	0.9		<0.03	0.43	0.7	2.94
2009	AL94/1700		1000	13	37.2		3	3	4	0.6		<0.02	0.22	<0.5	1.56
2010	AL94/1701		850	19	36.3		<3	3	4	0.6		0.14	0.19	<0.5	1.5
2011	AL94/2061	153	420	40	30.9	6.4	12	6	11	3.2	236	0.27	0.76	1.3	5.16
2012	AL94/1702		440	23	26.4		8	5	7	6.2		<0.03	0.52	<0.5	6.18
2013	AL94/1703		570	34	25.7		6	6	18	2.9		0.17	0.38	0.8	6.63
2014	AL94/1704		1200	23	29.5		3	4	4	1.8		0.13	0.23	<0.5	4.02
2016	AL94/1706		770	16	35.7		3	2	3	2.2		<0.01	0.15	<0.5	1.73
2017	AL94/2062	128	420	68	34.2	49.5	6	7	<1	<0.5	203	<0.04	0.45	1.1	3.89
2018	AL94/2063	165	570	24	34.8	26.5	<3	3	5	2.9	159	<0.02	0.31	<0.5	3.03
2019	AL94/1707		300	14	20		15	7	15	7.9		0.44	1	1.3	7.33
2020	AL94/2064	84	1200	62	37.4	28.2	<3	4	4	5.6	72	<0.02	0.23	<0.5	1.81
2022	AL94/2065	237	840	42	32.4	63.3	7	6	9	4.3	164	<0.03	0.53	<0.5	3.88
2023	AL94/2066		530	56	30.9		8	5	5	2.2		<0.03	0.52	1	5.95
2024	AL94/2067	112	430	29	36.7	25.7	9	4	13	2.4	110	0.24	0.7	0.8	3.44
2025	AL94/2059	202	1200	46	28	14.9	13	10	15	3.8	236	0.37	0.96	1.5	4.9
2042	AL94/1708		560	16	29		10	5	10	6.5		0.25	0.6	1.1	4.22
4001	AL94/1709		910	12	27.8		16	9	24	<0.5		0.47	1.22	1.4	1.67
4002	AL94/1710		570	9	7.8		36	10	29	1.4		0.99	2.65	3.2	3.08
4005	AL94/1713		920	11	6.9		39	13	67	2.4		1.31	3.07	3.3	2.71
4006	AL94/2068	215	700	24	31.7	19.1	7	6	4	1	141	0.15	0.45	<0.5	6.79
4007	AL94/2069	194	1000	23	38.3	10.5	<3	6	4	0.8	56	<0.02	0.15	<0.5	2.38
4008	AL94/2072	144	230	35	34.5	11.7	3	4	5	0.8	98	0.13	0.29	<0.5	3.91
4009	AL94/2073	193	780	31	30.2	12.6	10	6	11	1.5	152	0.13	0.84	1	4.71
4022	AL94/1715		350	25	32.5		6	6	7	0.8		<0.03	0.44	0.8	6.93
4023	AL94/1716		300	18	33		4	4	3	0.9		0.16	0.28	<0.5	3.63
4024	AL94/1717		730	21	28.4		<3	5	6	1.2		<0.02	0.33	0.7	4.8
4025	AL94/1718		460	23	34.9		6	3	6	2.2		0.12	0.38	0.7	2.84
4026	AL94/1719		280	12	35.4		3	2	5	<0.5		<0.02	0.22	0.5	2.43
4028	AL94/1721		390	12	30.9		5	2	5	<0.5		0.06	0.27	<0.5	5.27
4029	AL94/1722		460	13	33.3		4	2	4	<0.5		0.13	0.16	<0.5	3.7
4031	AL94/1724		880	17	27.9		15	6	16	<0.5		0.3	0.86	1.7	3.01
4032	AL94/1725		370	33	31.4		5	6	4	2.3		<0.03	0.31	<0.5	3.03
4033	AL94/2074	130	300	20	36.4	7.3	5	3	9	0.9	107	<0.02	0.32	0.5	3.28
4034	AL94/2081	144	570	19	24.7	6.5	21	11	34	1.5	198	0.53	1.46	1.9	5.54
4035	AL94/2075	119	1200	49	30.1	5.8	13	6	22	2	60	<0.02	0.88	1.5	3.17
4036	AL94/2076		590	84	28.3		10	8	20	1.4		0.27	0.7	1.2	5.37
4038	AL94/2077		970	42	30.5		7	9	12	2.1		0.17	0.66	<0.5	3.26
4042	AL94/2078		760	55	26.4		10	6	12	1.3		0.25	0.7	1.2	8.22
4043	AL94/2079	192	430	63	28.6	42.4	8	8	7	1.4	223	<0.03	0.6	0.7	7.49
4044	AL94/2080	147	2400	30	30.8	82.9	7	6	8	1.7	121	0.09	0.54	1.2	4.45
4045	AL94/2082	25	1000	19	8.2	2	65	16	76	1.7	216	1.74	4.39	6.3	3.37
4046	AL94/2085	148	440	25	40.1	13.2	3	3	6	0.5	58	<0.02	0.21	<0.5	1.77
4047	AL94/2086	203	1300	23	31	9.9	11	7	15	1.8	288	0.32	0.81	1.4	6.12
4048	AL94/2087	116	850	17	23.2	4	25	9	38	1.4	129	0.55	1.76	2.3	2.99
4049	AL94/2088	159	620	27	32.7	16.9	7	4	8	1.2	130	<0.02	0.56	0.6	4.71

SAMPLE NUMBER	LAB NUMBER	La_ppm INAA	Lu_ppm INAA	Mg_pct ICP-OES	Mn_ppm ICP-OES	Mo_ppm INAA	Na_ppm INAA	Nd_ppm INAA	Ni_ppm ICP-OES	P_pct ICP-OES	Pb_ppm ICP-OES	Rb_ppm INAA	Sb_ppm INAA	Sc_ppm INAA
		0.1	***0.05***	***0.01***	***1***	***2***	***10***	***5***	***1***	***0.001***	***2***	***5***	***0.1***	***0.1***
2001	AL94/1692	3.4	0.08			3	2750	<5				86	1.1	1.3
2002	AL94/1693	2.3	<0.05			<2	2000	<5				63	0.6	0.9
2005	AL94/1696	3.5	0.06			<2	2290	<5				84	0.9	1.3
2006	AL94/1697	3.5	<0.05			<2	3380	<5				75	0.9	1.6
2007	AL94/1698	1.5	<0.05			<2	1480	<5				42	0.5	0.6
2008	AL94/1699	3.2	0.06			6	2400	<5				<5	0.8	1.3
2009	AL94/1700	1.9	<0.05			4	1250	9				29	0.5	0.7
2010	AL94/1701	1.8	<0.05			<2	887	<5				19	0.4	0.6
2011	AL94/2061	5.2	0.1	3.13	7912	4	3310	5	35	1.4	52	150	1.2	2.2
2012	AL94/1702	4.2	0.05			6	2870	<5				170	1.2	1.6
2013	AL94/1703	3.5	<0.05			<2	3800	10				200	0.8	1.2
2014	AL94/1704	2.1	<0.05			<2	1330	<5				100	0.5	0.7
2016	AL94/1706	1	<0.05			<2	738	<5				35	0.3	0.4
2017	AL94/2062	3.4	0.09	2.49	6674	3	1940	<5	<1	1.251	37	73	0.9	1.5
2018	AL94/2063	2.2	<0.05	1.88	10405	3	1820	<5	19	0.789	24	85	0.7	0.9
2019	AL94/1707	8.1	0.14			3	6680	10				300	1.8	3
2020	AL94/2064	1.8	<0.05	1.1	8333	<2	1070	<5	9	0.306	19	37	0.7	0.7
2022	AL94/2065	3.8	0.08	3.37	13446	<2	2110	<5	28	0.74	35	85	0.8	1.3
2023	AL94/2066	3.6	0.09			3	2430	<5				89	1	1.5
2024	AL94/2067	4.9	0.09	1.65	7928	8	3120	8	<1	0.739	47	78	0.9	2.1
2025	AL94/2059	7.2	0.14	3.74	9973	11	4860	<5	5	1.434	51	93	1	2.8
2042	AL94/1708	5.3	0.1			3	3310	<5				180	1.2	2
4001	AL94/1709	9.2	0.2			<2	6910	9				49	0.9	4.7
4002	AL94/1710	20	0.39			<2	18300	16				63	1.7	9.7
4005	AL94/1713	21	0.49			<2	13100	25				38	2.6	13
4006	AL94/2068	3	0.07	2.87	5600	3	2700	<5	13	1.15	22	88	0.8	1.4
4007	AL94/2069	1.3	<0.05	2.43	9649	2	921	<5	<1	0.346	7	45	0.4	0.5
4008	AL94/2072	2	<0.05	2.01	6286	<2	1670	<5	9	0.603	23	89	0.7	0.9
4009	AL94/2073	4.9	0.09	2.82	4743	<2	4510	11	10	0.877	25	57	0.9	2.4
4022	AL94/1715	3.3	0.07			<2	3320	<5				73	1.1	1.6
4023	AL94/1716	2.2	<0.05			<2	2030	<5				22	0.8	0.9
4024	AL94/1717	3.1	<0.05			<2	2350	<5				53	0.9	1
4025	AL94/1718	2.9	0.06			4	2150	<5				48	0.9	1.2
4026	AL94/1719	1.6	<0.05			<2	1860	<5				11	0.6	0.7
4028	AL94/1721	2.8	<0.05			3	2000	<5				68	0.8	0.9
4029	AL94/1722	1.7	<0.05			2	1310	<5				30	0.3	0.5
4031	AL94/1724	7	0.11			<2	5640	8				54	0.9	2.9
4032	AL94/1725	2.5	<0.05			2	1720	<5				77	0.8	0.9
4033	AL94/2074	2.1	<0.05	2.52	3189	5	1920	6	1	0.504	24	42	0.7	0.9
4034	AL94/2081	9.4	0.2	3.85	5546	11	7220	14	41	1.212	55	66	1.5	5.1
4035	AL94/2075	6.6	0.16	2.21	6807	3	5650	8	17	0.39	11	40	0.9	2.8
4036	AL94/2076	5.6	0.14			6	3820	<5				<5	1.3	2.1
4038	AL94/2077	4.4	0.07			4	2810	<5				43	1.2	1.9
4042	AL94/2078	4.6	0.1			5	4050	<5				65	1.3	2.3
4043	AL94/2079	4.2	0.12	3.22	12979	<2	3340	<5	17	1.14	31	67	1.5	2
4044	AL94/2080	3.9	0.1	2.81	8225	5	2830	9	107	0.964	28	64	1	1.7
4045	AL94/2082	33	0.61	1.16	1891	8	22200	38	36	0.239	49	65	4.1	14
4046	AL94/2085	1.2	0.06	1.47	4705	2	1170	<5	<1	0.255	9	14	0.3	0.6
4047	AL94/2086	4.9	0.09	3.12	8190	4	4370	5	18	0.959	41	110	1.3	2.4
4048	AL94/2087	12	0.23	1.76	7794	4	10500	10	7	0.446	34	48	1.9	5.7
4049	AL94/2088	3.4	0.08	1.71	6277	4	2930	<5	11	0.554	39	69	0.9	1.6

SAMPLE NUMBER	LAB NUMBER	Sm_ppm INAA	Sr_ppm INAA	Ta_ppm INAA	Tb_ppm INAA	Th_ppm INAA	Ti_pct ICP-OES	U_ppm INAA	V_ppm ICP-OES	Y_ppm ICP-OES	Yb_ppm INAA	Zn_ppm INAA	Zr_ppm ICP-OES
		0.1	*300*	*0.5*	*0.5*	*0.1*	*0.01*	*0.1*	*2*	*1*	*0.05*	*20*	*1*
2001	AL94/1692	0.7	1400	<0.5	<0.5	0.4		<0.1			**0.37**	**3100**	
2002	AL94/1693	0.4	740	<0.5	<0.5	0.8		<0.1			**0.27**	**2800**	
2005	AL94/1696	0.7	1100	<0.5	<0.5	<0.1		<0.1			**0.33**	**3600**	
2006	AL94/1697	0.6	940	<0.5	<0.5	0.6		<0.1			**0.49**	**2600**	
2007	AL94/1698	0.3	1100	<0.5	<0.5	0.3		<0.1			**0.26**	**1600**	
2008	AL94/1699	0.6	880	<0.5	<0.5	0.5		<0.1			**0.3**	**2200**	
2009	AL94/1700	0.3	1100	<0.5	<0.5	<0.1		<0.1			**<0.05**	**1800**	
2010	AL94/1701	0.2	830	<0.5	<0.5	0.2		<0.1			**0.28**	**2100**	
2011	AL94/2061	1	400	<0.5	<0.5	0.8	0.02	<0.1	9	4	**0.6**	**2800**	5
2012	AL94/1702	0.8	1000	<0.5	<0.5	0.7		<0.1			**0.35**	**3800**	
2013	AL94/1703	0.6	1000	<0.5	<0.5	0.4		<0.1			**0.32**	**3700**	
2014	AL94/1704	0.3	1300	<0.5	<0.5	0.3		<0.1			**0.2**	**4300**	
2016	AL94/1706	0.2	920	<0.5	<0.5	0.2		<0.1			**<0.05**	**1900**	
2017	AL94/2062	0.6	2000	<0.5	<0.5	<0.1	0.01	0.8	6	4	**0.44**	**3800**	4
2018	AL94/2063	0.4	880	<0.5	<0.5	0.3	0.01	<0.1	4	3	**0.28**	**3500**	6
2019	AL94/1707	1.5	<300	<0.5	<0.5	1.1		0.9			**0.77**	**3400**	
2020	AL94/2064	0.3	1100	<0.5	<0.5	0.3	0.01	<0.1	3	3	**<0.05**	**3500**	4
2022	AL94/2065	0.7	1200	<0.5	<0.5	0.6	0.01	<0.1	5	4	**0.24**	**4000**	7
2023	AL94/2066	0.7	750	<0.5	<0.5	0.5		<0.1			**0.32**	**3700**	
2024	AL94/2067	1	840	<0.5	<0.5	0.7	0.02	<0.1	8	5	**0.44**	**2500**	5
2025	AL94/2059	1.2	1800	<0.5	<0.5	1.1	0.02	<0.1	11	4	**0.53**	**4100**	7
2042	AL94/1708	0.9	1200	<0.5	<0.5	0.8		0.5			**0.51**	**2400**	
4001	AL94/1709	1.8	810	<0.5	<0.5	1.6		0.8			**1.26**	**1400**	
4002	AL94/1710	4	750	<0.5	<0.5	2.8		1.2			**2.48**	**750**	
4005	AL94/1713	5	<300	<0.5	0.7	3		0.9			**2.96**	**470**	
4006	AL94/2068	0.6	1400	<0.5	<0.5	0.4	0.01	<0.1	6	4	**0.31**	**2200**	4
4007	AL94/2069	0.2	1200	<0.5	<0.5	0.2	<0.01	<0.1	2	3	**0.1**	**2100**	4
4008	AL94/2072	0.4	790	<0.5	<0.5	<0.1	0.01	<0.1	4	3	**<0.05**	**1900**	4
4009	AL94/2073	0.9	1200	<0.5	<0.5	0.7	0.03	0.6	11	4	**0.53**	**2200**	4
4022	AL94/1715	0.7	700	<0.5	<0.5	0.5		<0.1			**0.41**	**2600**	
4023	AL94/1716	0.4	1100	<0.5	<0.5	0.3		0.4			**0.34**	**2100**	
4024	AL94/1717	0.5	1100	<0.5	<0.5	0.4		<0.1			**0.26**	**2100**	
4025	AL94/1718	0.6	600	<0.5	<0.5	0.5		<0.1			**0.29**	**2600**	
4026	AL94/1719	0.3	1000	<0.5	<0.5	0.4		<0.1			**0.16**	**1400**	
4028	AL94/1721	0.4	1100	<0.5	<0.5	0.3		<0.1			**0.23**	**1200**	
4029	AL94/1722	0.2	1100	<0.5	<0.5	0.3		<0.1			**0.21**	**1400**	
4031	AL94/1724	1.3	1200	<0.5	<0.5	1.1		0.5			**0.73**	**3000**	
4032	AL94/1725	0.5	1300	<0.5	<0.5	0.2		<0.1			**0.19**	**2500**	
4033	AL94/2074	0.4	1300	<0.5	<0.5	0.3	0.01	<0.1	4	4	**0.23**	**2300**	3
4034	AL94/2081	1.9	1700	<0.5	<0.5	1.2	0.06	<0.1	27	8	**1.21**	**2300**	8
4035	AL94/2075	1.2	1500	<0.5	<0.5	0.9	0.04	0.4	17	5	**0.69**	**1700**	6
4036	AL94/2076	1.1	1200	<0.5	<0.5	0.4		<0.1			**0.58**	**3000**	
4038	AL94/2077	0.9	450	<0.5	<0.5	0.6		<0.1			**0.43**	**4200**	
4042	AL94/2078	0.9	1400	<0.5	<0.5	0.8		0.5			**0.52**	**3500**	
4043	AL94/2079	0.8	<300	<0.5	<0.5	1	0.02	<0.1	7	4	**0.59**	**3200**	8
4044	AL94/2080	0.7	<300	<0.5	<0.5	0.6	0.02	<0.1	8	4	**0.34**	**3500**	5
4045	AL94/2082	5.9	730	<0.5	1	4.3	0.17	1.9	67	14	**3.57**	**510**	11
4046	AL94/2085	0.2	770	<0.5	<0.5	0.3	0.01	<0.1	2	3	**0.15**	**2100**	3
4047	AL94/2086	0.9	1800	0.8	<0.5	1.1	0.02	<0.1	11	4	**0.47**	**2400**	6
4048	AL94/2087	2.1	1200	<0.5	<0.5	2.2	0.07	1	25	6	**1.34**	**1200**	7
4049	AL94/2088	0.6	1300	<0.5	<0.5	0.6	0.02	<0.1	6	4	**0.34**	**1600**	4