Atlin TGI, Part III: Geological Setting and Style of Mineralization at the Joss'alun Occurrence, Atlin Area (NTS 104N/2SW), MINFILE 104N136

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KEYWORDS: Massive sulphide, geologic mapping, geochronology, U-Pb, 40Ar/39Ar, radiolarian, Kutcho, intraoceanic arc, Joss'alun, Cache Creek terrane.

INTRODUCTION

Ministry of Energy and Mines personnel encountered massive, copper-rich sulphide mineralization during regional geological mapping in the southern Atlin area. Now named the Joss'alun occurrence, its discovery is a direct consequence of the joint federal and provincially funded Atlin Targeted Geoscience Initiative (Lowe and Mihalynuk, 2002). We report here on updates to map data released following the discovery (Mihalynuk, 2002) as well as new petrographic, isotopic age and micropaleontological age data.

GEOGRAPHIC LOCATION

The Joss'alun discovery is located approximately 75 kilometres southeast of the placer mining town of Atlin (Figure 1). Access is by helicopter, which can be chartered in Atlin. Float planes can land at a 1.4 km long lake, locally known as "Windy Lake", about 7.5 km north of the occurrence. Atlin is 92 km south of the Alaska Highway, and 182 km from Whitehorse, which is the nearest major center with a national airport. Closest road access to the Joss'alun is a very rough, fire abatement road that ends at Kuthai Lake, 30 km northwest of the occurrence. A proposed road route to the Tulsequah Chief minesite (50 km southwest of Joss'alun) is within about 22 km of the occurrence. Redfern Resources, operator of the Tulsequah project, was issued a project approval certificate in December 2002. Nearest tidewater is Taku Inlet, about 70 km to the southwest, and accessible by barge from the confluence of the Tulsequah and Taku rivers, about 12 km downstream from the Tulsequah Chief deposit.

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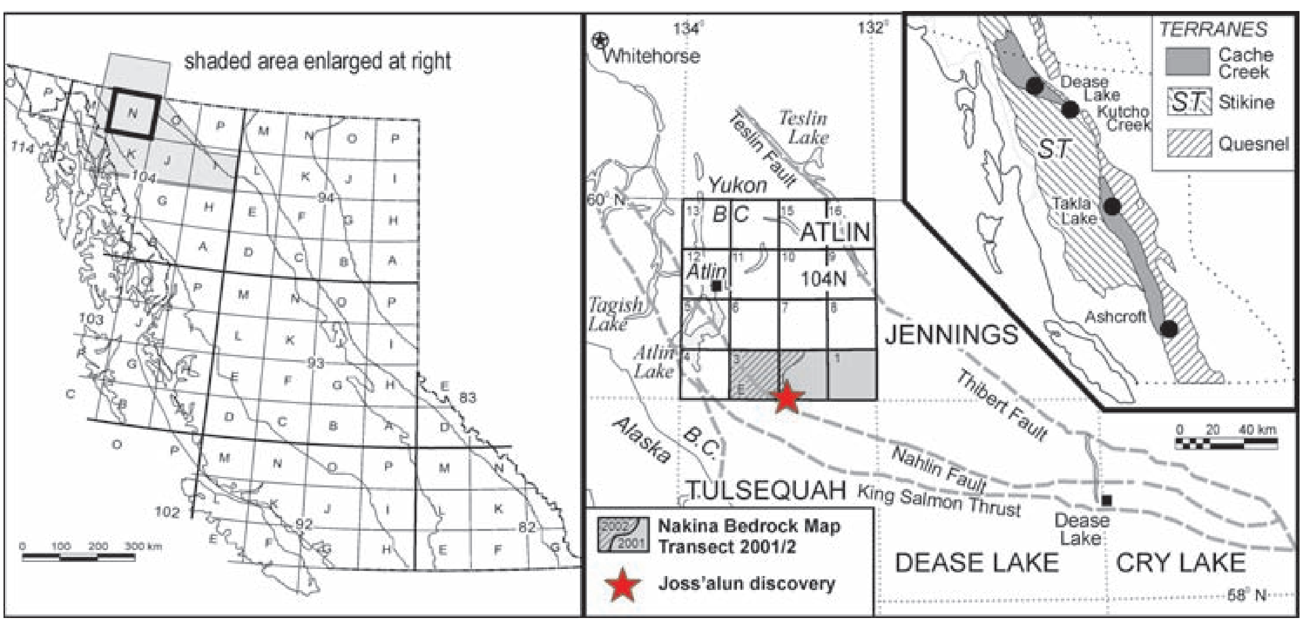

Figure 1. Location of the Joss'alun discovery and Nakina mapping transect in northwestern British Columbia.

EXPLORATION OF JOSS'ALUN AND REGION

At the time of discovery, there were no signs of previous work at the Joss'alun occurrence. One prior claim block was staked in 1985, located 2.5 km southwest, near the head of the valley. It was recorded as the NOW claims by Noranda Mining and Explorations Inc. (ARIS Report Number 14364), but follow-up geochemical surveys failed to detect base or precious metal anomalies and the claim was left to lapse with no further work recorded. Nearest mineral claims in good standing were located approximately 30 km to the northwest (104N/3) and an equal distance to the south in the northern Tulsequah map area (104K/10). Nearest known mineralization recorded in MINFILE is more than 10 km to the southeast in the Tulsequah map area. Known as "Inklin" or "Yeth Creek" (MINFILE 104K022), it is a series of galena-sphalerite-chalcopyrite-bearing quartz veins, hosted by submarine volcanic rocks correlated with the Late Triassic Stuhini Group. Within the Atlin map area, the nearest mineral occurrences are: an asbestos occurrence 17 km to the northwest, known as "Focus Mountain" (MINFILE 104N071); a magnesite occurrence, 19 km northwest, known as "Sloko River" or "Nahlin Fault" (MINFILE 104N083); and the "Nakina River" limestone occurrence, 20 km to the northeast (MINFILE 104N094).

A public announcement of the discovery was made a 14:00 on September 13. By 15:00, Aurum Geological (Whitehorse) had staked the KNACK claims (2 units) over the main mineralized zone, on behalf of Copper Ridge Explorations Inc. (Carleson, 2002). While the Aurum crew was at work, the Northair Group arrived and staked the adjoining 12 unit D claims to the northwest, on behalf of Tennajon Resources Ltd. Beset by Friday the 13^{th} problems, the Imperial Metals Corp. crew arrived the following day, and staked the 16 unit DARK claims to the southeast of the main mineralized zone. Immediately prior to the release date, the Northair Group staked 3 claim blocks within 13 km northeast of Joss'alun: the 20 unit, HF #1 block, the 4 unit, TOP #1, and the 8 unit VM claims. At the tail end of the staking activity, the 18 unit Bobit 3 block, located by Peter Burjowski, was staked 8 km to the west-southwest. No further activity was recorded prior to the date of publication in December.

DISTRIBUTION AND CHARACTER OF MINERALIZATION

Mineralization is exposed at and below tree line on the western side of a broad valley containing a north-flowing stream. Mineralized outcrops are low and rubble-strewn. They occur within, and south of, a shallowly incised, east-flowing creek that joins the main stream about 0.5 km (map distance) below tree line (Photo 1). Mineralization that was encountered farthest to the northwest is a 30 cm wide, copper stained and gossanous zone on the northern side of the creek cut near UTM 620271,6544371N, EPE: 4m (Note that EPE = estimated position error that is calculated by a proprietary algorithm). Mineralization occurs intermittently over a distance of about 255 m, across the area

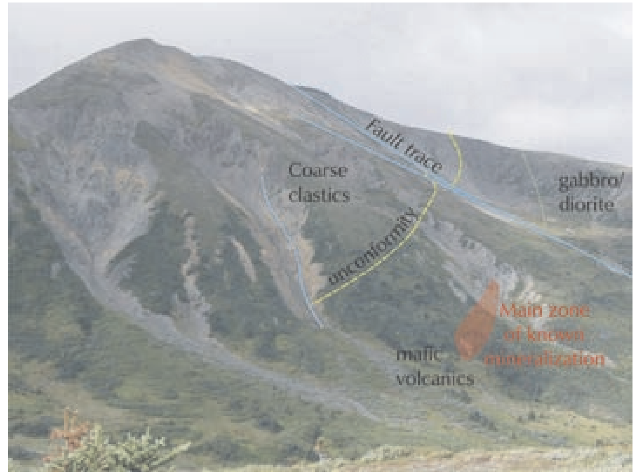

Photo 1. An overview of mineralization at the Joss'alun taken from about 1 km to the southeast at about the same stratigraphic/structural position. Shading indicates the approximate extent of known mineralization.

of low scattered outcrops containing massive sulphide lenses (UTM 620381N 6544322N, EPE: 5m) to a very low, isolated, and competent outcrop amongst the trees and brush above a gossanous seep. Here (UTM 620460E 6544252N, EPE: 10m), discordant chalcopyrite veins (3-4 cm thick) cut the outcrop, and several pieces of fist-sized float of semi-massive sulphide were found resting on the outcrop. Sulphide float presumably tumbled down slope from above, but a crisscross traverse through subalpine fir upslope did not reveal the source. Southeast of the veined outcrop, the mineralized zone disappears beneath cover in the broad valley.

Across the valley axis, about one kilometre to the east-southeast, blebs of chalcopyrite, up to 0.5 cm across, occur within mafic breccia, along the trend of the host rocks in the discovery zone, and at approximately the same stratigraphic level.

Mineralization consists of a series of stacked lenses of semi-massive chalcopyrite, lesser pyrite, and quartz-chlorite gangue in gossanous outcrops with weak copper staining. Host rocks are dominantly mafic volcaniclastics: pillow breccia and aquagene lapilli to ash tuff and tuffite. Lens thickness ranges up to approximately 1m. Thicknesses of 30cm are more typical. Lateral extent of the lenses is difficult to determine due to the generally low and rubbly nature of the outcrops. However, some are exposed for more than 3m. Both chalcopyrite and pyrite within the lenses appear brecciated (Photo 2). Pyrite clasts display a variety of textures including framboidal and having angular intergrowths of chalcopyrite (Photo 2a). Bedding within the mafic volcanic unit is not everywhere obvious, but the lenses appear to be concordant. Chalcopyrite also occurs as veins up to 5cm thick that are clearly discordant.

Mineralization is strongest in a ~10 x 30 m area near the center of the known limits of the mineralized zone. Mihalynuk (2002) reported analytical results from two chip and three grab samples from near the center of the strongly mineralized area. These occur in a digital publication for-

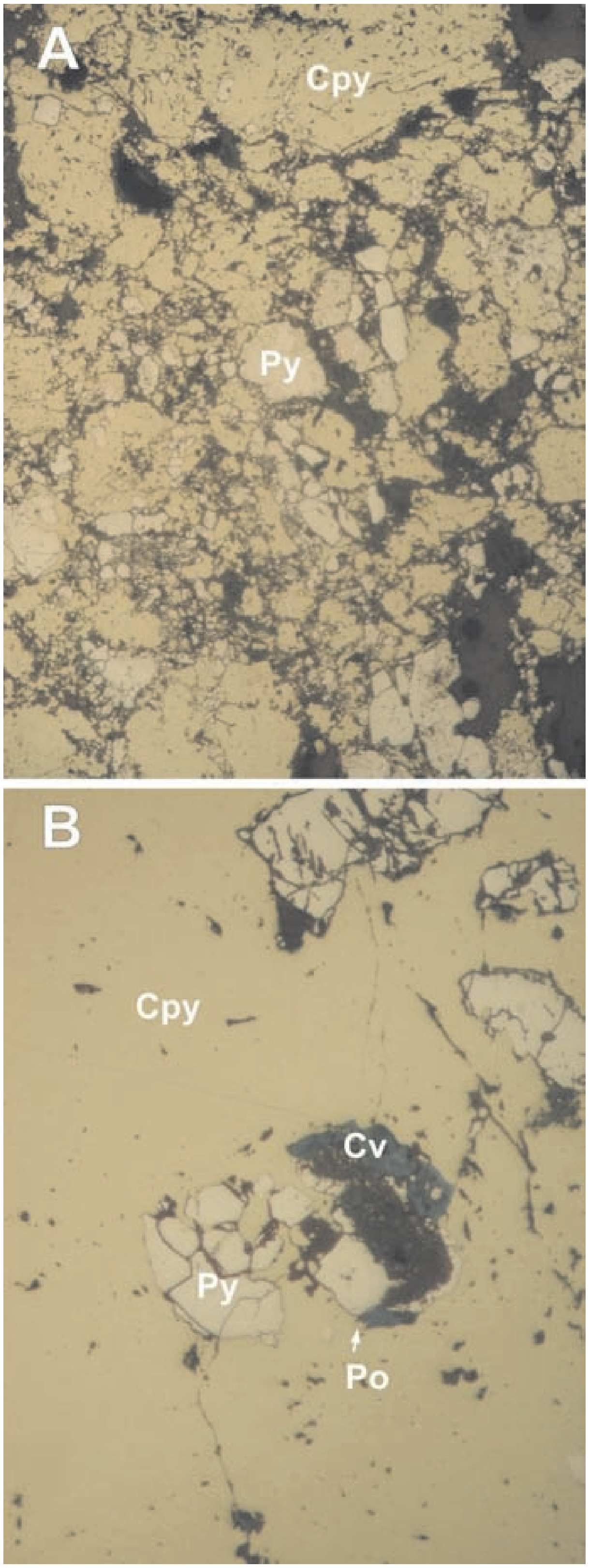

Photo 2. Reflected light photomicrograph of massive sulphide textures, A) brecciated textures with pyrite having various textures. B) Representative mineralogy: Cpy = chalcopyrite, Py = pyrite, Cv = covellite, Po = minor bleb of pyrrhotite. Length of photo represents about 5mm.

mat and are reproduced here in Tables 1and 2 for the benefit of clients who do not have on-line access.

GEOLOGICAL SETTING

Rocks underlying the Joss'alun discovery are part of the oceanic Cache Creek terrane. In the area around the Joss'alun stratigraphic and structural contacts parallel the general northwestern structural fabric of the Cordillera. However, some low angle contacts display variable directions because of interplay with topography. Dominant rock units are: harzburgite, gabbro, submarine basalt flows, flow breccia, and tuffaceous rocks and coarse, quartz-rich clastic strata. They are exposed in this same approximate order from north to south (Figure 2) and deepest to shallowest crustal level.

HARZBURGITE

Bright orange to dun-weathering harzburgite is a conspicuous, very dense and magnetic ultramafic rock that comprises a large part of the Nahlin ultramafic body. It is a resistant unit that crosses the valley about 300 m north of the Joss'alun occurrence (Figure 2). It has a characteristic knobby weathering appearance due to resistant orthopyroxene crystals and crystal trains in a less resistant olivine matrix. Shearing of orthopyroxene to produce crystal trains is a texture produced at mantle temperatures, and supports an interpreted origin as part of the ancestral Earth's mantle. It has been variably serpentinized, and now comprises up to 100% serpentine. Strongly serpentinized zones are exceptionally magnetic and produce an extreme positive aeromagnetic anomaly (Dumont *et al.*, 2001).

GABBROIC ROCKS

Gabbro occurs as resistant, blocky, grey outcrops between harzburgite and basalt. Contacts with the harzburgite are not exposed; they are inferred to be faults. Gabbro contacts with basalt are intrusive with evidence for multiple episodes of intrusion. Zones of intense epidote alteration are common, suggesting vigorous hydrothermal alteration.

MAFIC VOLCANICLASTIC ROCKS

Dark green pillow breccia, and lapilli and ash aquagene tuff dominate the unit. Ferruginous chert and laminated, muddy limestone are minor components. Bedding is poorly displayed, as the volcanic rocks tend to be massive. Where chert and ash tuff or tuffite beds occur, the bedding is well displayed. The unit on the east side of the valley displays good pillow textures. Steeply dipping dark green dikes up to one metre thick, cut the volcaniclastic rocks, but have not been observed in the unconformably overlying coarse quartz-rich clastic unit.

Age of the volcaniclastic unit is Permian as determined by identification of radiolaria extracted from interbedded ferruginous chert from the east side of the valley (Figure 2, Photo 3, Table 3). A submarine origin for the unit is indicated by pillows, radiolarian-bearing Fe-rich chert, and

TABLE 1
INDUCTIVELY COUPLED PLASMA MASS SPECTROMETRY (15G SAMPLE) ANALYTICAL RESULTS FROM SAMPLES COLLECTED JOSS'ALUN MINERALIZED ZONE NEAR UTM 620381E 6544322N

Field Number	UTM Easting	UTM Northing	sample type	Cu ppm	Cu %	Mo ppm	Pb ppm	Zn ppm	Ag ppb	Ni ppm
MMI02-33-15	620396	6544343	grab	68830.7	6.88	4.19	9.42	629.1	3279	24.7
MMI02-34-6	620460	6544252	grab	97698.56	9.77	2.65	6.22	276.0	983	11.0
MMI02-34-9	620355	6544318	grab	74502.47	7.45	4.09	8.30	293.3	1032	17.2
MMI02-34-10-1	620381	6544322	90cm chip	33509.12	3.35	3.65	4.00	165.1	841	17.1
MMI02-34-10-2	620381	6544322	35cm chip	66465.67	6.65	3.00	2.72	241.7	1391	32.1

	Mn ppm	As ppm	U ppm	Au ppb	Th ppm	Sr ppm	Cd ppm	Sb ppm	Bi ppm	V ppm	Ca %
MMI02-33-15	996	50.4	< .1	153.3	< .1	0.5	0.73	2.32	2.19	104	0.02
MMI02-34-6	1065	5.6	< .1	191.4	< .1	1.0	0.98	0.15	1.75	154	0.06
MMI02-34-9	821	14.2	< .1	114.4	< .1	8.0	0.67	0.76	0.49	106	0.33
MMI02-34-10-1	1257	28.9	< .1	95.1	< .1	0.6	0.16	0.94	0.65	229	0.04
MMI02-34-10-2	1338	39.0	0.1	111.5	< .1	0.5	0.29	0.68	0.92	206	0.03

	Fe %	P %	La ppm	Cr ppm	Mg %	Ba ppm	Ti %	B ppm	Al %	Na %	K %
MMI02-33-15	17.68	0.014	< .5	27.7	1.62	1.7	0.014	< 1	2.56	0.003	< .01
MMI02-34-6	17.22	0.018	< .5	7.3	2.23	12.5	0.058	< 1	3.39	0.001	0.01
MMI02-34-9	14.71	0.013	0.6	14.1	1.20	7.1	0.079	< 1	2.38	0.001	< .01
MMI02-34-10-1	18.62	0.022	0.6	19.4	3.06	5.2	0.036	< 1	4.31	0.001	< .01
MMI02-34-10-2	20.83	0.024	< .5	94.9	3.76	10.0	0.033	< 1	4.65	0.001	< .01

	Co ppm	W ppm	Sc ppm	Tl ppm	S %	Hg ppb	Se ppm	Te ppm	Ga ppm	Sampl g
MMI02-33-15	578.7	2.8	8.9	0.2	7.24	471	169.8	6.61	9.2	15
MMI02-34-6	287.1	1.3	8.5	0.02	2.8	108	44.2	2.02	10.8	15
MMI02-34-9	272.1	2.5	4.9	0.17	3.5	435	204.9	12.46	7.9	15
MMI02-34-10-1	320.5	0.5	12.6	0.06	3.4	369	102.3	3.90	18.7	15
MMI02-34-10-2	641.2	0.3	14.4	0.09	4.3	270	108.5	3.56	18.7	15

UTM = Universal Transverse Mercator, Zone 8, NAD 83

Analysis by Acme Analytical Laboratories Ltd.

Analysis by ICPMS, aqua regia digestion, 15 g sample (Group 1F15)

TABLE 2
FIRE ASSAY ANALYTICAL RESULTS

Field Number	UTM E	UTM N	% Cu
MMI02-33-15	620396	6544343	7.342
MMI02-34-6	620460	6544252	10.146
MMI02-34-9	620355	6544318	7.659
MMI02-34-10-1	620381	6544322	3.493
MMI02-34-10-2	620381	6544322	7.330
detection limit			0.001

UTM = Universal Transverse Mercator, Zone 8, NAD 83
Analysis by Acme Analytical Laboratories Ltd.
Analysis by ICP, aqua regia digestion, 1 g sample (Group 7AR)

laminated interpillow micrite (conodont results from the micrite are pending).

COARSE QUARTZ-RICH CLASTIC UNIT

Quartz-rich clastic rocks comprise the peak 1300 m west of the Joss'alun discovery (here informally called "Jos Peak", *el.* 1865m), and extend over 5 km to beyond the southern border of the map area (Figure 2). This unit is highly variable. It includes: well laminated siltstone, thin to thick-bedded clean sandstone to wacke, coarse boulder conglomerate, fault scarp debris with blocks in excess of 10m long, and clastic carbonate layers. At "Jos Peak", a very well exposed section of coarse quartz wacke displays an angular unconformable relationship with underlying basalt. A red-weathering basal conglomerate containing oxidized cobbles of basalt grades rapidly upwards into

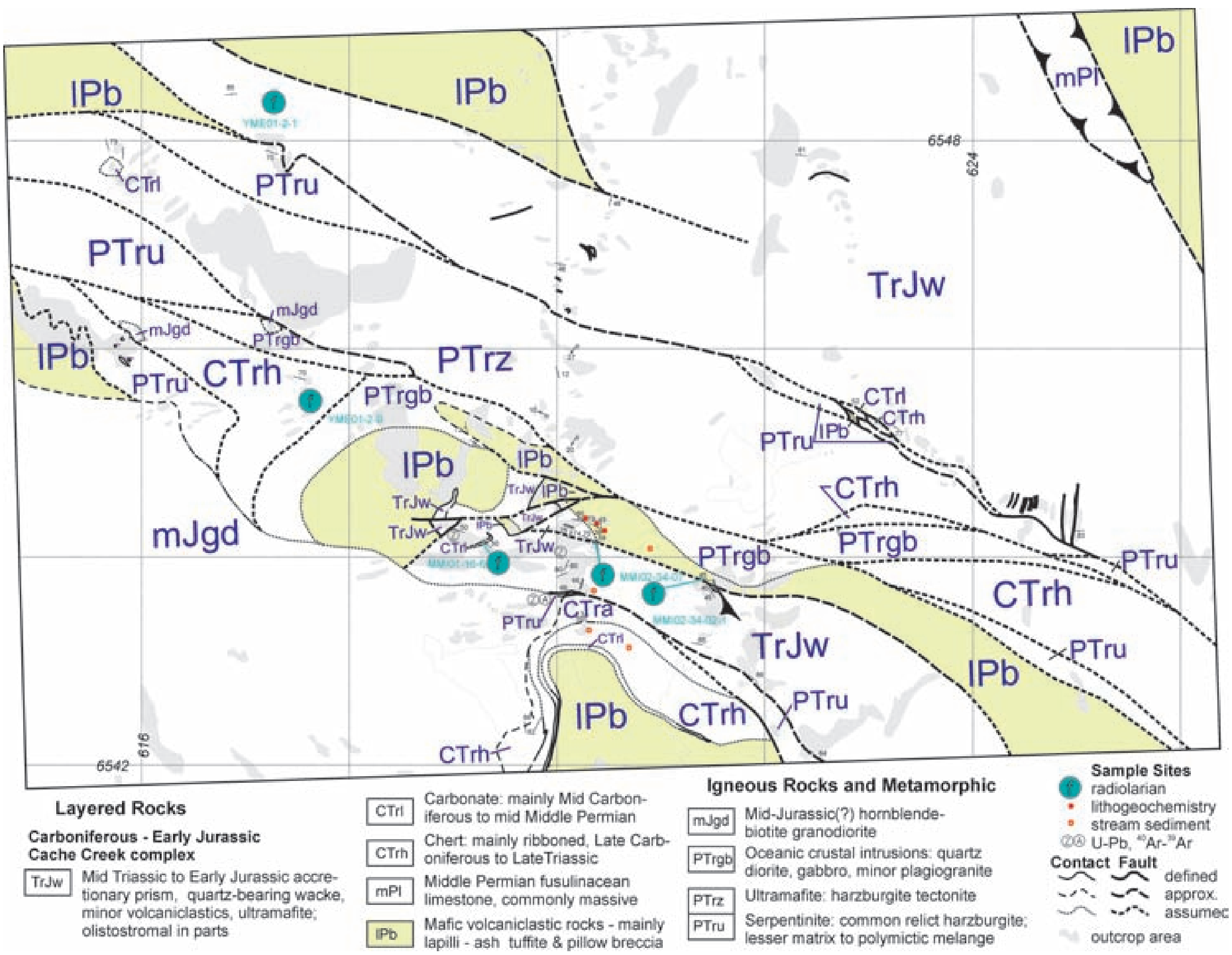

Figure 2. Geologic setting of the Joss'alun discovery.

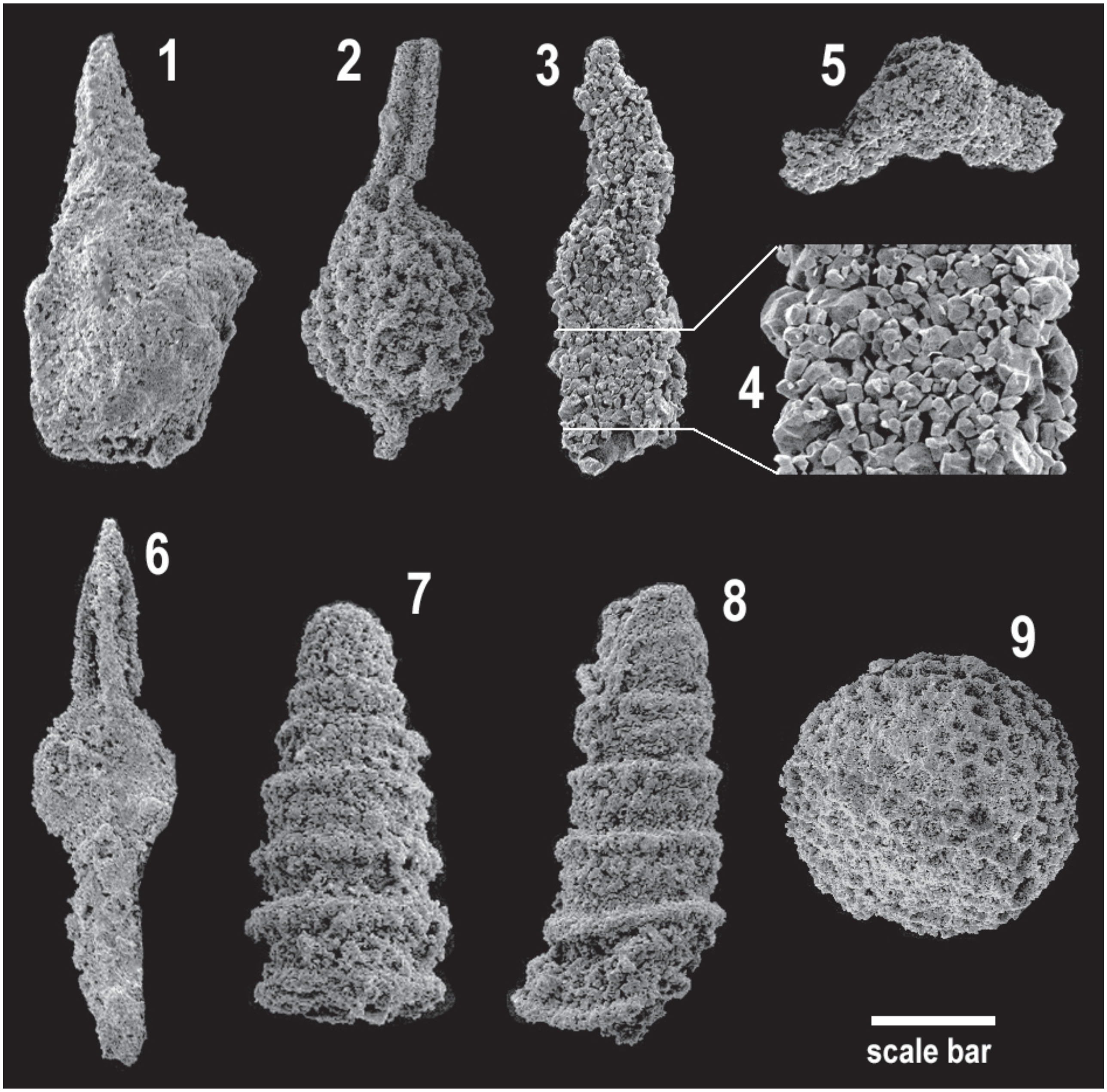

Photo 3. Scanning electron photomicrograph of radiolaria extracted from chert within the strata hosting the massive sulphide mineralization (radiolarian pictures 1 to 5). And from a ~10m long block of chert within the coarse clastic unit (radiolarian pictures 6 to 9). Fossil identifications are listed in Table 3.

quartz-rich silt, coarse sandstone, and boulder conglomerate containing both locally derived and abundant exotic intrusive clasts up to 1 m diameter, as well as angular, olistostromal intraclasts, commonly several metres long, and near the unit margins, in excess of 10 m in long dimension. Despite and abundance of chert clasts and megaclasts, intact chert has not been observed in depositional contact with the unit. Chert along strike to the north is of Late Paleozoic age (YME01-2-9 *see* Table 1 of Mihalynuk *et al.*, 2003a this volume). In addition to mafic volcanic and chert clasts, fusulinid-bearing limestone and sparse serpentinite clasts are also clearly derived from the adjacent Cache Creek terrane; however, porphyritic and coarse-grained granitic boulders have no obvious nearby source (Photo 4). Carbonate layers, as thick as ~5 m, that occur near the middle of the exposed unit may be entirely from an eroded source rather than deposited *in situ*. Samples were collected for conodont extraction, however, contamination from older sources is expected and results are pending. One megaclast of ribbon chert located near the base of the unit, contains radiolaria of Middle Triassic age (Table 3). Detrital zircons extracted from a sample of quartz sandstone from near the peak yielded a surprisingly uniform population of Late Permian ages. The quartz-rich clastic unit is

TABLE 3
RADIOLARIAN IDENTIFICATIONS BY F. CORDEY FROM TWO SAMPLES OF CHERT NEAR THE JOSS'ALUN DISCOVERY (*SEE* PHOTO 3)

Sample Number	Radiolarian Identification	Number and scale in Photo 3	Age
MMI02-34-2-1	***Pseudoalbaillella*** sp.,	1, scale bar 30 µm	Permian
MMI02-34-2-1	***Entactinia*** sp.,	2, scale bar 30 µm	Permian
MMI02-34-2-1	?***Follicucullus*** sp. (enlargement shows recrystallized quartz of shell)	3 & 4, scale bar 30 mm	Permian
MMI02-34-2-1	probable fragment of central part and sphere of Latentifistulid	5, scale bar 40 µm	Permian
MMI02-34-7	***Pseudostylosphaera coccostyla compacta***	6, scale bar 40 µm	Middle Triassic
MMI02-34-7	***Triassocampe*** sp.	7, scale bar 30 µm	Middle Triassic
MMI02-34-7	***Triassocampe*** sp.	8, scale bar 30 µm	Middle Triassic
MMI02-34-7	spumellaria gen. et sp. indet.	9, scale bar 40 µm	Middle Triassic

clearly younger than the Cache Creek lithologies that it contains as clasts, and it is older than an unfoliated granodiorite pluton to the north and west, which thermally metamorphoses the unit and yields a 40Ar/39Ar age of Middle Jurassic (*see* next section). Aitken (1959) mapped this unit as wacke of possible Triassic to Jurassic age. Such an age assignment is consistent with the new age data presented here.

NAKINA RIVER STOCK

Unfoliated hornblende-biotite granodiorite intrudes the base of the south and western flanks of "Jos Peak". It is part of the Nakina River stock, named by Aitken (1959). Approximately 18 km long and averaging about 4 km wide, the body is elongated parallel to the northwest structural fabric of the region. It is described further in Bath (2003, this volume). Hornblende and biotite were extracted from a fresh sample of the stock, collected from ~1km southeast of the peak. They reveal a Middle Jurassic age.

ISOTOPIC AGE DATING

New isotopic age determinations are reported for two samples collected from the "Jos Peak" area. Quartz sandstone collected from the peak yielded Permian detrital zircons, and hornblende/biotite extracted from the Nakina River stock yielded a Middle Jurassic age.

SHRIMP METHODOLOGY

Following the separation of heavy minerals using heavy liquids, the sample separates were passed through a Frantz LB-1™ magnetic separator to purify zircon, titanite and monazite. Zircons were again passed through a magnetic field in order to concentrate grains with the least magnetic susceptibility that, depending on quantity of zircons, ranged from 10° to 1° side-slope setting. Handpicking of the zircons to optimize clarity and lack of fractures resulted in selection of grains from each sample, but no effort was

Photo 4. Coarse conglomerate within the clastic unit contains granitoid boulders up to 1 metre in diameter.

TABLE 4
U-PB ISOTOPIC DETERMINATIONS FROM DETRITAL ZIRCONS OF SAMPLE VN01-A03

Spot name*	U (ppm)	Th (ppm)	Th/U	Pb (ppm)	204Pb (ppb)	204Pb/ 206Pb	±204Pb/ 206Pb	f206	208Pb/ 206Pb	±208Pb/ 206Pb	206Pb/ 238U	±206Pb/ 238U	207Pb/ 235U	±207Pb/ 235U	207Pb/ 206Pb	±207Pb/ 206Pb	206Pb/ 238U	±206Pb/ 238U	207Pb/ 206Pb	±207Pb/ 206Pb	Conc. (%)
VN-01-A03 (Z7062; 59.0218°N 132.9249°E)																					
7062-22.1	125	21	0.18	4	5	0.001108	0.0005555	0.01921	0.04616	0.0244	0.03741	0.00067	0.23956	0.04695	0.04645	0.00896	237	4	22	543	1100.9
7062-5.1	253	79	0.32	9	2	0.00029	0.0001588	0.00503	0.09788	0.0084	0.03758	0.00053	0.25623	0.01472	0.04945	0.00267	238	3	169	131	140.5
7062-70.1	59	22	0.38	2	0	0.000219	0.001577	0.0038	0.20236	0.0616	0.03804	0.00136	0.37153	0.13229	0.07084	0.02478	241	8	953	947	25.3
7062-8.1	140	70	0.51	6	3	0.000648	0.0003678	0.01123	0.1517	0.02363	0.03816	0.00064	0.24042	0.03201	0.04569	0.00594	241	4	0	0	0
7062-47.1	142	36	0.26	5	1	0.000259	0.0003255	0.00448	0.07569	0.01917	0.03833	0.00074	0.27999	0.02896	0.05298	0.00526	242	5	328	242	73.9
7062-30.1	127	33	0.26	5	5	0.001178	0.0004921	0.02041	0.04702	0.04959	0.03839	0.00061	0.21771	0.04237	0.04113	0.0079	243	4	0	0	0
7062-4.1	76	29	0.39	3	0	0.00001	0.00001	0.00017	0.14796	0.01127	0.0385	0.00061	0.33838	0.01399	0.06375	0.00232	244	4	733	79	33.2
7062-45.1	64	16	0.27	3	0	0.00001	0.00001	0.00017	0.13405	0.01132	0.03859	0.00069	0.30806	0.01587	0.0579	0.00267	244	4	526	105	46.4
7062-59.1	47	14	0.31	2	2	0.001371	0.0018883	0.02375	0.11041	0.0724	0.03863	0.00149	0.22395	0.16006	0.04205	0.02981	244	9	0	0	0
7062-44.1	176	71	0.41	7	0	0.00001	0.00001	0.00017	0.13332	0.00706	0.03869	0.00053	0.28168	0.00838	0.0528	0.0013	245	3	320	57	76.4
7062-55.1	165	56	0.35	7	1	0.000192	0.0003364	0.00333	0.12707	0.01434	0.03881	0.00058	0.29365	0.02968	0.05487	0.00538	245	4	407	236	60.3
7062-7.1	31	9	0.31	1	0	0.000372	0.0010792	0.00644	0.15391	0.04425	0.03953	0.00146	0.33225	0.09609	0.06096	0.0172	250	9	638	638	39.2
7062-42.1	126	19	0.15	5	4	0.000933	0.0004167	0.01618	0.03718	0.01662	0.03962	0.00067	0.21605	0.03727	0.03955	0.00671	250	4	0	0	0
7062-43.1	135	38	0.29	5	1	0.000282	0.0002783	0.00489	0.09399	0.02459	0.03966	0.00061	0.29843	0.02609	0.05458	0.00459	251	4	395	201	63.5
7062-35.1	234	100	0.44	10	3	0.000352	0.0001836	0.00609	0.14378	0.01046	0.04046	0.00058	0.27066	0.01793	0.04852	0.00305	256	4	125	142	204.9

Notes:

Number + letter designation represents zircon grain #, dot + number represents spot number on grain.

Uncertainties reported at one sigma (absolute) and are calculated by numerical propagation of all known sources of error (Stern, 1997).

f206 refers to mole fraction of total 206Pb that is due to common Pb; data have been common Pb corrected according to procedures outlined in Stern (1997).

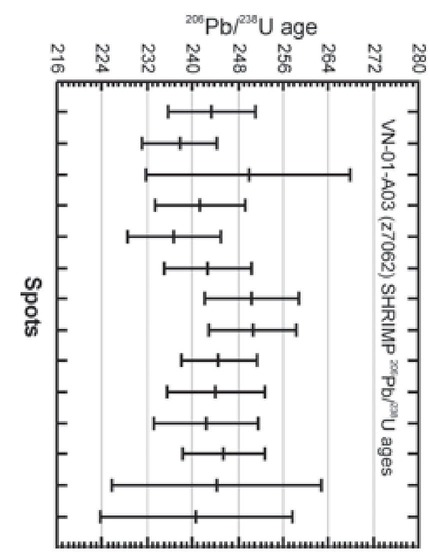

Figure 3. ^{206}Pb-^{238}U age date plots detrital zircon grains from sample VN01-A03

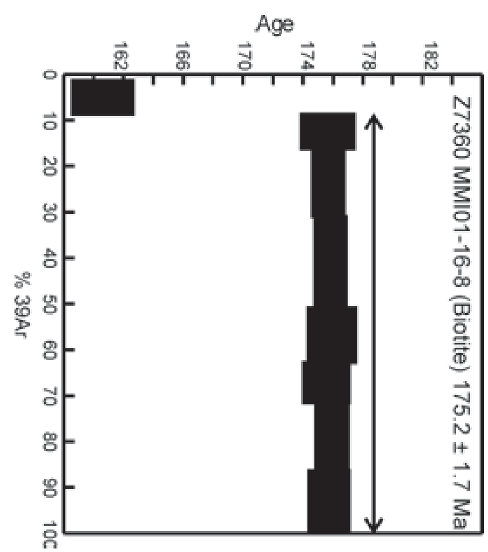

Figure 4. Ar-release spectra for sample MMI01-16-8.

made to separate or select grains on the basis of morphology. Grains were polished and examined in cathodoluminescent (CL), transmitted and reflected light. The former method enhances details of the internal growth structures of the zircon and can highlight the presence of xenocrystic cores that, unless avoided, may skew individual results to apparently older ages. Analyses use O^- as primary beam, the 563.5 Ma zircon standard, BR266 and data reduction techniques outlined in Stern (2000). All uncertainties are quoted and displayed at 1s level of uncertainty and all quoted ages represent $^{207}Pb/^{206}Pb$ ages (Table 4), unless otherwise noted.

AGE OF DETRITAL ZIRCONS

Results of the analyses gave concordant results and thus the data is displayed in terms of $^{206}Pb/^{238}U$ age (Figure 3, Table 4). The data has a surprisingly unimodal age population. If there are multiple age sources, they cannot be resolved at the uncertainty levels present. It is clear that all grains are derived from a Permian-age body (or bodies) with no indication of other sources. This small population has a 33% probability of missing components that represent less than 1 in 10 of the overall population (Sircombe, 2000). Nevertheless, the results would indicate that other sources, if present, represent a minor component only

NAKINA RIVER STOCK

The methodology for the $^{40}Ar/^{39}Ar$ isotopic age dating reported here is the same as that in Mihalynuk *et al.* (2003, this volume), except that biotite was dated instead of hornblende. Biotite from the Nakina River stock gave a good plateau age (Table 5) with only slight evidence of Ar-loss in the earliest steps (Figure 4). A plateau age based upon ~91% of ^{39}Ar released in the high temperature steps is 175.2 ±1.7 Ma concordant with ages determined from other Middle Jurassic plutons in the Atlin area (*e.g.* Symons, 1998).

DISCUSSION

Deposit type and mode of genesis of the mineralization at the Joss'alun occurrence are undetermined at this time. However, the host rocks were clearly deposited in a submarine setting as is shown by pillow textures in flow breccia, radiolarian chert, and laminated lime mud. Within the mineralized zone, submarine textures are more equivocal; however, tuffaceous chert (lacking easily identified radiolaria) and vague bedding in lapilli ash tuffite support a submarine origin. Massive sulphide lenses are apparently stratabound. Some of the geochemical characteristics of the mineralization, particularly the elevated cobalt, are typical of submarine massive sulphide deposits, like Cyprus and Besshi-types (Lefebure and Ray, 1995). On the basis of the above, we tentatively interpret the sulphide lenses as syngenetic. However, discordant chalcopyrite veins are relatively common, and an epigenetic origin for the sulphide lenses cannot be ruled out at this preliminary stage in our investigation.

Results of trace and major element analyses are pending. However, the textural and mineralogical characteristics of pillow breccia are similar to those observed elsewhere in the Nakina Transect, and these dominantly show a thoeiitic arc affiliation (English *et al.*, 2002). It is likely that the host rocks of the Joss'alun massive sulphide are primitive volcanic arc strata as well. Furthermore, detrital zircons from the overlying quartz-rich coarse clastic unit suggest a nearby felsic volcanic/intrusive center that was exhumed between Middle Triassic and Middle Jurassic times. The most likely source of magmatic rocks of only Permian age is Cache Creek terrane itself, probably from felsic arc component, coeval with French Range - Kutcho Creek volcanism (*see* age tabulation in Mihalynuk *et al.,* 1999); petrochemistry in Mihalynuk and Cordey (1997)

TABLE 5
AR ISOTOPIC DATA FOR SAMPLE MMI01-16-8

Power[a]	Volume ^{39}Ar x10^{-11} cc	$^{36}Ar/^{39}Ar$	$^{37}Ar/^{39}Ar$	$^{38}Ar/^{39}Ar$	$^{40}Ar/^{39}Ar$	%^{40}Ar ATM	*$^{40}Ar/^{39}Ar$	f_{39}[b] (%)	Apparent Age Ma[c]
MMI01-16-8 Biotite; J=.00293400 (Z7360; 59.0169°N 132.9121°E)									
Aliquot: A									
2.4	0.1912	0.0249±0.0060	0.111±0.015	0.123±0.011	24.442±1.100	30.2	17.063±1.800	1.4	88.13±9.08
2.8	1.0187	0.0063±0.0009	0.022±0.004	0.102±0.011	33.582±0.368	5.6	31.717±0.404	7.3	160.52±1.96
3.0	1.0451	0.0010±0.0009	0.020±0.002	0.104±0.011	35.022±0.315	0.9	34.723±0.360	7.5	175.02±1.73
3.5	2.0508	0.0012±0.0005	0.021±0.002	0.100±0.011	35.086±0.191	1	34.727±0.211	14.8	175.04±1.02
3.9	2.7579	0.0018±0.0004	0.013±0.002	0.099±0.011	35.286±0.201	1.5	34.761±0.212	19.9	175.21±1.02
4.2	1.653	0.0022±0.0009	0.017±0.002	0.109±0.011	35.418±0.213	1.8	34.778±0.320	11.9	175.29±1.54
4.6	1.2107	0.0015±0.0008	0.026±0.003	0.104±0.011	35.151±0.254	1.3	34.707±0.306	8.7	174.94±1.47
5.5	2.0505	0.0009±0.0005	0.022±0.002	0.103±0.011	35.049±0.183	0.8	34.777±0.221	14.8	175.28±1.06
12.0	1.8968	0.0017±0.0006	0.035±0.002	0.101±0.011	35.234±0.238	1.4	34.741±0.272	13.7	175.11±1.31

a: As measured by laser in % of full nominal power (10W)
b: Fraction 39Ar as percent of total run
c: Errors are analytical only and do not reflect error in irradiation parameter J
d: Nominal J, referenced to FCT-SAN=28.03 Ma (Renne *et al* ., 1994)
All uncertainties quoted at 2σ level

and English *et al.* (2002). Terranes adjacent to the Cache Creek contain numerous Mesozoic and Late Paleozoic sources of magmatic arc zircons, as well as older zircons derived from adjacent continental masses, or recycled from pericratonic sediments, and therefore are unlikely source terrains.

Extreme facies changes, abundant intraclasts and fault scarp debris that characterize the quartz-rich coarse clastic unit indicate rapid deposition in a tectonically active environment. Lack of any trace of an *in situ*, exposed source for coarse granitoid boulders is puzzling. Perhaps the granitoid source was removed by translation on an arc-parallel fault? The same fault, or series of faults, may be responsible for creation of the basin in which the coarse clastics were deposited, and synsedimentary deformation. Transcurrent faults with similar characteristics are common features of along the axes of most modern arcs.

SUMMARY AND FUTURE WORK

Our work around the Joss'alun discovery, which amounts to less than one full day of field mapping, leaves many questions unanswered. The proposed syngenetic origin for the mineralization requires testing. Analysis of the Pb isotopic signature of chalcopyrite will be undertaken at the Pacific Isotopic and Geochemical Research for isotopic and Geochemical Research (UBC) in order to determine if the mineralization is coeval with Permian host rocks, and to compare with the lead isotopic composition of the Kutcho Creek massive sulphide deposit.

More detailed mapping is required to understand the interplay of synsedimentary faulting and mineralization. Detailed mapping should be extended to the western flank of "Jos Peak" and southeast of the main valley where mafic volcanic rocks are in contact with the coarse clastic unit, but have not been walked over. Age constraints for the coarse clastic unit need to be improved in order to understand the duration of sedimentation and its role, if any, in the mineralizing event. To this end, a ~1m thick granitic dike that cuts the upper part of the coarse clastic unit will be processed for U-Pb age dating. Plus, detrital zircon age determinations on five boulders are in progress. Geochronologic results from the boulders may provide a fingerprint of the source terrain. Could they be remnants of the Kutcho arc?

Northern Cache Creek terrane has long been considered unprospective for volcanogenic deposits. However, the possibility of arc-related volcanogenic massive sulphide mineralization at the Joss'alun discovery forces us to reevaluate this large region of northern British Columbia and southern Yukon. Given that these rocks comprise one of the most common rock types in the Nakina-Atlin area (Aitken, 1959; Mihalynuk *et al.*, 1996; Mihalynuk *et al.*, 2002; English *et al.*, 2002), there is much exploration still to be done.

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