JURASSIC STRATIGRAPHIC RELATIONSHIPS IN THE BABINE AND TELKWA RANGES (93L/10, 11, 14, 15)

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KEYWORDS: Jurassic stratigraphy, Hazelton Group, Telkwa Formation, Nilkitkwa Formation, Smithers Formation, Ashman Formation, Trout Creek assemblage, Babine Range, Telkwa Range, structure, tectonic history.

INTRODUCTION

This report discusses preliminary observations on Jurassic volcanic stratigraphy in the Babine and Telkwa ranges. These observations are based on 1:50 000 mapping conducted as part of the Babine and Telkwa projects (Figure 1-23-1).

The Babine project began in 1984 with 1:10 000 mapping of the Dome Mountain gold camp (MacIntyre, 1985). In 1986 and 1987 the remaining part of the Babine Range, including most of the Driftwood Creek (93L/15) and Quick (93L/10) map sheets, was mapped at 1:50 000 scale (MacIntyre *et al.*, 1987; MacIntyre and Desjardins, 1988).

The Telkwa project is an enhancement to the Babine project. The objective is to extend previous mapping westward to cover important mineral camps in the Telkwa Range. Parts of the Smithers (93L/14) and Telkwa River (93L/11) map sheets (Figure 1-23-1) were previously mapped by R.V. Kirkham and J.Koo (1984). Mapping in 1988 was concentrated in areas not covered by this earlier work, thus providing complete 1:50 000 coverage of the two map sheets. In 1989 mapping will extend southward into the Thautil River map sheet (93L/6).

An important part of the Telkwa project is the recompilation and publication at 1:20 000 scale of detailed mapping by R.V. Kirkham on Hudson Bay Mountain. This work, which has not been previously published, was completed between 1963 and 1968 while Dr. Kirkham was in the employ of the British Columbia Department of Mines. Dr. Kirkham also did regional mapping in the Bulkley Valley and Telkwa River areas during this period and his data have been incorporated into this report.

REGIONAL GEOLOGIC SETTING

West-central British Columbia is part of the Stikine terrane. This terrane, which is believed to have travelled north from low paleolatitudes in Late Cretaceous or Early Tertiary time, includes: submarine calcalkaline to alkaline volcanic island arc rocks of the Late Triassic Takla Group; subaerial to submarine calcalkaline volcanic, volcaniclastic and sedimentary rocks of the Early to Middle Jurassic Hazelton Group; Late Jurassic and Early Cretaceous successor basin sedimentary rocks of the Bowser Lake, Skeena and Sustut groups; and Late Cretaceous to Tertiary calcalkaline continental volcanic arc rocks of the Kasalka, Ootsa Lake and Goosly Lake groups. The younger volcanic rocks occur sporadically throughout the area, mainly in subsided fault blocks and grabens that may be the remains of cauldron subsidence complexes.

Potassium-argon isotopic dating has defined three major magmatic events. These are the Late Triassic to Early Jurassic Topley intrusions, the Middle to Late Cretaceous Bulkley intrusions and the Eocene Babine intrusions (Carter, 1981). Mineral deposits in the area are associated with emplacement of these intrusions. The most economically important exploration targets are porphyry copper and molybdenum deposits and mesothermal and epithermal precious metal veins. A few small massive sulphide occurrences have also been discovered.

TECTONIC HISTORY

The tectonic history of the area is divisible into three distinct regimes. From Early to Middle Jurassic time an extensive calcalkaline island arc evolved, with a possible back-arc basin located to the east. This was followed from late Middle Jurassic to Early Cretaceous time by development of the Bowser and Nechako successor basins. Thick deposits of molasse derived from an uplifted Skeena Arch and Omineca crystalline belt accumulated within these basins. A major plate collision in Middle Cretaceous time resulted in uplift of the Coast Range and extensive folding of rocks to the east. Debris was shed eastward across the area from the rising metamorphic-plutonic complex and this was

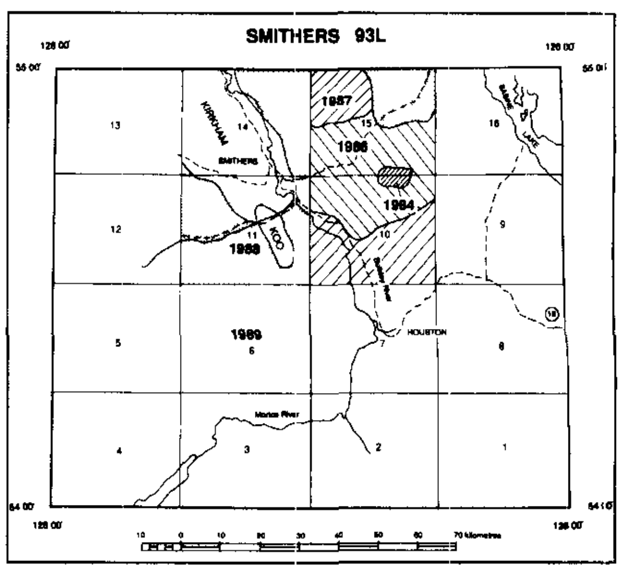

Figure 1-23-1. Location of the 1988 project area.

British Columbia Ministry of Energy, Mines and Petroleum Resources, Geological Fieldwork, 1988, Paper 1989-1.

followed by the growth of a north-trending Andean-type volcanic arc in Middle to Late Cretaceous time. A transtensional tectonic regime in Late Cretaceous to Early Tertiary time produced the basin-and-range geomorphology that controls the current map pattern of the area. The latest tectonic event appears to be northeast shearing and tilting of fault blocks to the southeast (MacIntyre and Desjardins, 1988). This shearing has offset northwest-trending grabens that developed in Late Cretaceous to Early Tertiary time.

GEOLOGY OF THE STUDY AREA

The geology of the study area, as determined by fieldwork conducted from 1986 to 1988, is shown in Figure 1-23-2. Relationships between the different map units in the Telkwa and Babine ranges are shown diagrammatically in Figure 1-23-3. Table 1-23-1 lists the major stratigraphic and tectonic elements of the Stikine terrane as summarized by Richards (1988). This report will deal mainly with the Jurassic stratigraphy of the Babine and Telkwa ranges.

The Telkwa and Babine ranges consist of a series of uplifted and tilted fault blocks containing rocks ranging from early Jurassic to Tertiary in age. In general the fault blocks are tilted toward the Bulkley valley graben which separates the two ranges. Rocks of Cretaceous and Tertiary age are preserved within the graben. The graben is offset by several major northeast-trending shear zones of probable Tertiary age.

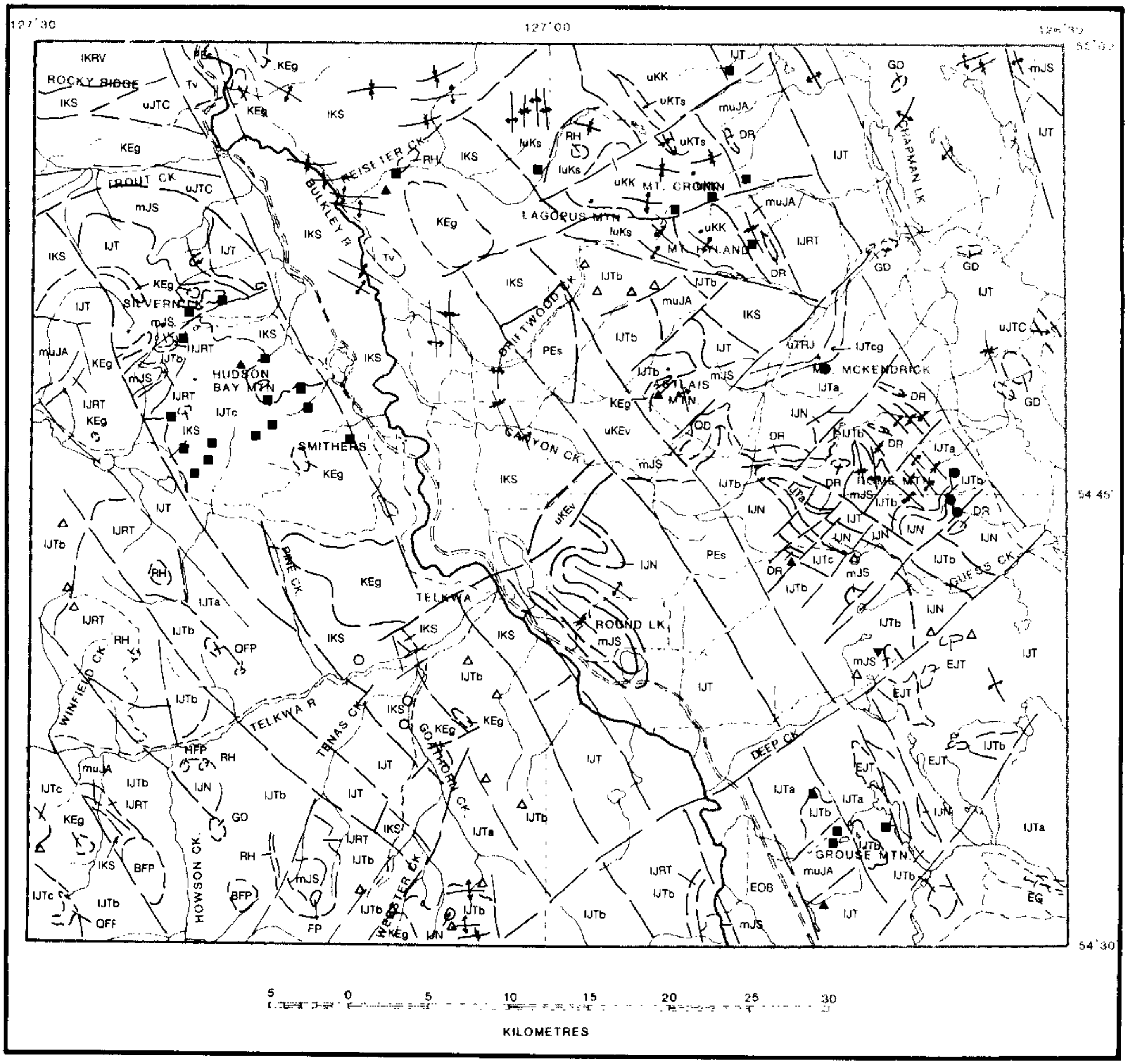

Figure 1-23-2. General geology of project area.

LEGEND

LAYERED ROCKS

PALEOCENE TO MIOCENE

Tv	basalt flows, breccia
EOB	Buck Creek Volcanics: andesite, dacite, breccia, minor basalt
PEs	shale, mudstone, greywacke

UPPER CRETACEOUS TO TERTIARY

OOTSA LAKE GROUP

uKEv	rhyolite, dacite, tuff, breccia, minor andesite
uKTs	tuff, shale, siltstone, greywacke

UPPER CRETACEOUS

KASALKA GROUP

uKK	Brian Boru Formation: porphyritic andesite, tuff, breccia, minor basalt

LOWER TO UPPER CRETACEOUS

luKs	red to maroon phyllite, shale, orange siltstone, chert-quartz pebble conglomerate, greywacke

LOWER CRETACEOUS (ALBIAN)

SKEENA GROUP

lKS	Red Rose Formation: shale, micaceous greywacke, chert, pebble conglomerate, mudstone, coal bearing
lKRV	Rocky Ridge Volcanics: anguite phyric flows, breccia, hornblende andesite, aphanitic basalt

UPPER JURASSIC (OXFORDIAN TO KIMMERIDGIAN)

BOWSER LAKE GROUP

uJTc	Trout Creek Assemblage: greywacke, conglomerate, siltstone, coquinoid sandstone, minor coal

LOWER TO UPPER JURASSIC

HAZELTON GROUP

MIDDLE TO UPPER JURASSIC (CALLOVIAN TO OXFORDIAN)

muJA	Ashman Formation: marine black shale, siltstone, greywacke

MIDDLE JURASSIC (BAJOCIAN TO CALLOVIAN)

mJS	Smithers Formation: feldspathic sandstone, greywacke, siltstone, shale, minor pebble conglomerate, very fossiliferous

LOWER JURASSIC (PLEINSBACHIAN TO TOARCIAN)

lJRT	Nilkitkwa Formation, Red Tuff Member: red, well-bedded air fall tuff, minor ash flow tuff
lJN	Nilkitkwa Formation: marine shale, calcareous siltstone, limestone, minor chert, conglomerate at base

LOWER JURASSIC (SINEMURIAN TO LOWER PLEINSBACCHIAN)

lJT	Telkwa Formation: undivided andesite, dacite, rhyolite, basalt, flows and pyroclastics
lJTc	Siliceous Pyroclastic Facies: quartz-feldspar phyric ash flows, ignimbrite, breccia, siliceous air fall tuff, red tuff, basalt, rhyolite flows.
lJTb	Basalt Flow-Red Tuff Facies: amygdaloidal angite phyric basalt, basaltic tuff, red tuff and epiclastics
lJTa	Andesitic Pyroclastic Facies: andesitic air fall tuff, breccia, feldspar phyric andesite flows, feldspathic epiclastics, minor basalt, rhyolite
lJTcg	Basal Conglomerate: heterolithic volcanic conglomerate

UPPER TRIASSIC OR LOWER JURASSIC

uTRJ	greenstone with granitic lenses

INTRUSIVE ROCKS

LATE CRETACEOUS TO EOCENE

KEg	undivided granitic intrusions; GD – granodiorite; OD – quartz dioritie; DR – diorite; RH – rhyolite; FP – feldspar porphyry, BFP – biotite-feldspar porphyry; HFP – hornblende-biotite-feldspar porphyry

EARLY JURASSIC

EJT	Topley Intrusions: undivided granitic intrusions

MINERAL OCCURRENCES

▲ porphyry Cu-Mo	Δ Cu-Ag veins and pods
■ Ag-Pb-Zn-Cu veins and shears	▼ Cu-Zn-Ag massive sulphide
● Au-Ag-Cu-Pb-Zn quartz veins	○ coal

HAZELTON GROUP

The Hazelton Group (Leach, 1910) is a calcalkaline island arc assemblage that evolved in Early to Middle Jurassic time. Tipper and Richards (1976) divide the group into three major formations in the Smithers map area (93L). These are the Late Sinemurian to Early Pliensbachian Telkwa Formation, the Early Pliensbachian to Middle Toarcian Nilkitkwa Formation and the Middle Toarcian to Early Callovian Smithers Formation.

TELKWA FORMATION (JT)

In the Telkwa Range, a thick section of early Jurassic volcanic rocks constitutes the type area for the Telkwa Formation of the Hazelton Group. Tipper and Richards (1976) describe the typical lithology as "reddish, maroon, purple, grey and green pyroclastic and flow rocks". The formation varies from marine to nonmarine and ranges from Sinemurian to Early Pliensbachian in age. The volcanics in the study area are almost exclusively subaerial and constitute the Howson subaerial facies of the formation. Similar sub-

STRATIGRAPHIC AND TECTONIC ELEMENTS
STIKINE TERRANE, BRITISH COLUMBIA

Post Orogenic	CENOZOIC	Late Tertiary	PLIE	Anahim Volcanics Chilcotin Lavas		BASALT		
					Poplar Butte Volcanics	BASALTIC		Development of basin and range morphology, regional Cordilleran uplift.
				ENDAKO GROUP	Buck Creek Volcanics			
Transtensional Volcanic Assemblages		Early Tertiary		OOTSA LAKE GROUP	Goosly Lake Volcanics Babine Volcanics	RHYOLITE TO BASALTIC	KASTBERG INTRUSIONS QUANCHUS INTRUSIONS BABINE INTRUSIONS NANIKA INTRUSIONS	Epoch of development of down-drop volcanic basins.
Molasse Assemblages	MESOZOIC	Cretaceous	U	KASALKA GROUP	Brian Boru Formation Tip Top Hill Formation Suskwa River Volcanics	Calc-alkaline andesitic to rhyolitic	BULKLEY INTRUSIONS	Begin uplift of Coastal crystalline belt - welding of Wrangellia and Alexandria to craton.
				Rocky Ridge Volcanics		Conglomerate Sandstone Alkaline Basalt		
			L	SKEENA-SUSTUT GROUP		Chert Pebble Congl. Sandstone Black shale, Sandstone, Congl		Begin uplift of Omineca crystalline belt - welding of Stikinia to craton.
		Jurassic	U	BOWSER LAKE GROUP	Deltaic Assemblages Trout Creek Assemblages Ashman Formation	Congl., Silst., Greywacke, Silst., Shale		Development of Bowser Basin.
Island Arc Assemblages			L	HAZELTON GROUP	Smithers Formation Nilkitkwa Formation	Calc-alkaline, marine and non-marine Volcanics and Sediments Polymictic Congl.	OMINICA INTRUSIONS TOPLEY INTRUSIONS	
		Triassic	U	TAKLA-STUHINI GROUP	Savage, Dewar, and Moosevale Formations	Alkaline Mafic Volcanics, Sediments and limestone		Stikinia an independent arc terrane, separated from craton.
	PALEOZ.	Permian		STIKINE ASSEMBLAGE		Limestone, Chert, Rhyolite, Andesite Basalt		
		Penn						
		Miss						Modified after Richards, 1988

aerial volcanic rocks crop out in the southern half of the Babine Range. Northeast of the map area the Howson facies grades into the Babine shelf and Kotsine submarine facies (Tipper and Richards, 1976).

The Telkwa Formation is Sinemurian or older based on sporadic fossil fauna within the stratigraphic succession (Tipper and Richards, 1976). In the Babine Range the formation is overlain by marine sedimentary beds containing Late Sinemurian to Pliensbachian pelecypods, predominantly *Weyla*. These rocks are part of the Nilkitkwa Formation. In the Telkwa Range the marine sedimentary beds of the Nilkitkwa Formation are absent or very thin; thin-bedded red tuffs that are mapped as the Red Tuff member of the Nilkitkwa Formation (Tipper, 1976) overlie the Telkwa Formation. In the Telkwa River area shallow-marine sedimentary beds of the Smithers and Ashman formations onlap the red tuffs. In the Goathorn Creek area the Smithers and Ashman formations are absent and the Early Cretaceous coal measures of the Skeena Group sit directly on Telkwa Formation (Koo, 1984).

Andesitic pyroclastics and flows are the predominant lithologies of the lower part of the Howson facies of the Telkwa Formation. A distinctive unit of interbedded amygdaloidal basalt flows and red tuffs overlies the andesitic pyroclastic package. In the Babine Range the basaltic flows are in part submarine. Locally felsic pyroclastics overlie and are interfingered with the basaltic flows and red tuffs.

A unit of well-bedded marine sediments and red tuffs overlies and is in part interbedded with the Telkwa volcanics. The sediments and red tuffs are mapped as part of the Nilkitkwa Formation. Tipper (1979) describes a similar stratigraphic sequence in the Whitesail Lake area.

Our mapping in the Babine and Telkwa ranges suggests the Telkwa Formation is divisible into four major facies. These facies are characterized by their predominant lithologies. In ascending stratigraphic order they are: (1) a heterolithic basal conglomerate; (2) maroon feldspathic tuffs, breccias, epiclastics and andesitic flows; (3) massive aphyric to augite-feldspar-phyric amygdaloidal flows and interbedded red tuffs

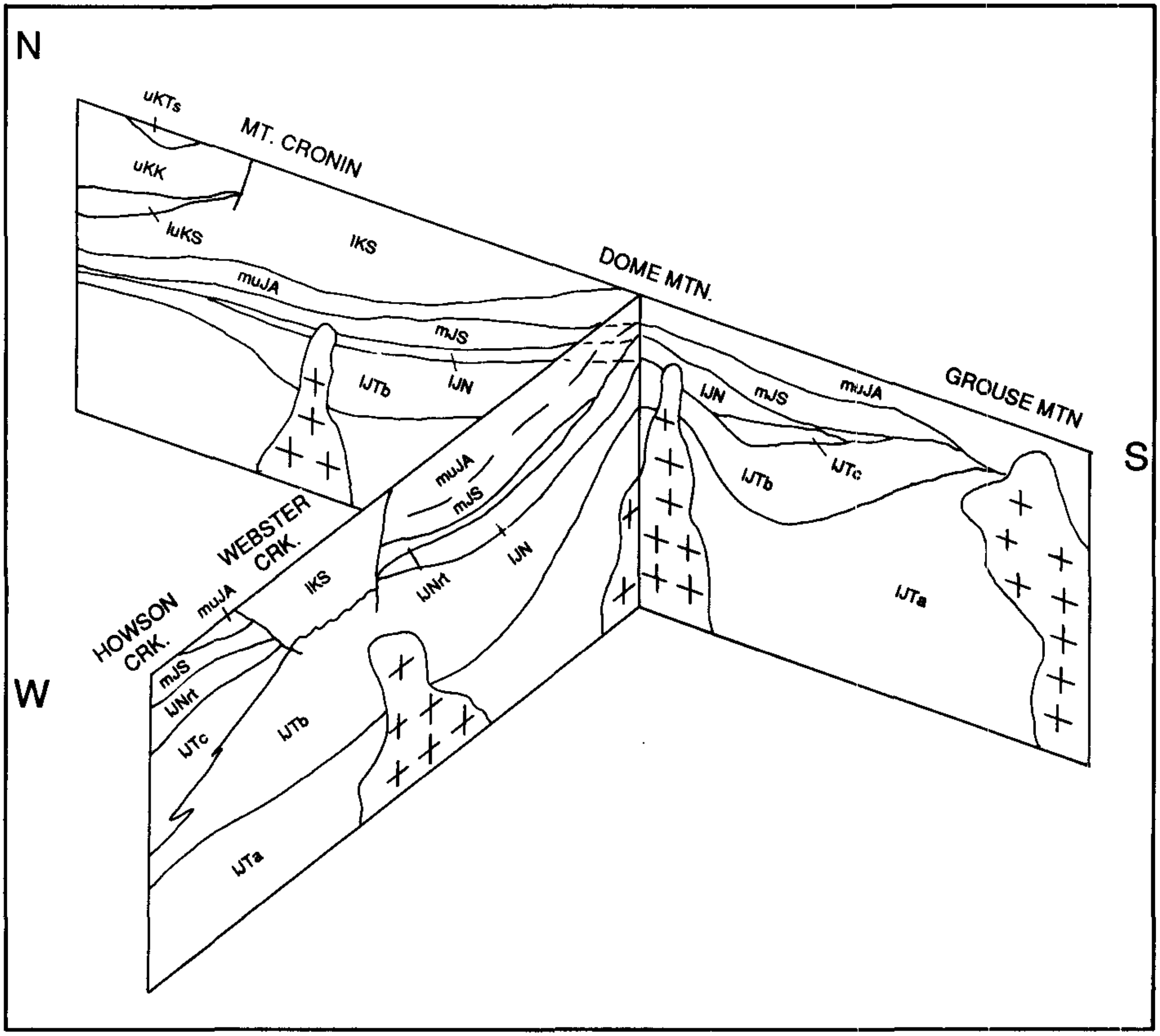

Figure 1-23-3. Stratigraphic fence diagram. *See* Table 1-23-1 for explanation of symbols.

or epiclastics; and (4) siliceous pyroclastics, rhyolite flows and minor red tuffs and basalt flows. The siliceous pyroclastic facies is only present locally; the andesitic pyroclastic and basaltic flow facies are widespread within the study area. Jurassic stratigraphic relationships between the Babine and Telkwa ranges are illustrated in Figure 1-23-4.

The contact between Facies 3 and 4 is generally gradational, both in a lateral and vertical sense, and is typical of a facies boundary. On Dome Mountain a heterolithic erosional conglomerate occurs at the contact between Facies 2 and 3 suggesting an unconformity separates a lower, predominantly andesitic pyroclastic package from an upper, essentially bimodal basalt-rhyolite package. Amygdaloidal flows have not been observed in the lower andesitic pyroclastic package and their absence may serve as a useful criterion for distinguishing the two divisions. Further work is required to confirm the validity of this subdivision.

We initially put the basaltic flows and red tuffs into the Nilkitkwa Formation because of the apparent unconformable relationship with underlying andesitic pyroclastics and apparent conformable relationship with overlying sediments of the Nilkitkwa Formation. However, in the Telkwa Range, a thick section of amygdaloidal flows and red tuffs, that we believe is correlative with similar rocks in the Babine Range, constitutes part of the type area for the Telkwa Formation. Therefore, in order to preserve the original definition of the Telkwa Formation, we also include these rocks as a facies of the Telkwa Formation.

Basal Conglomerate

As discussed in a previous report (MacIntyre *et al.*, 1987) the base of the Telkwa Formation may be exposed near the crest of Mount McKendrick. Here, a poorly-sorted heterolithic conglomerate containing leucogranite clasts is the

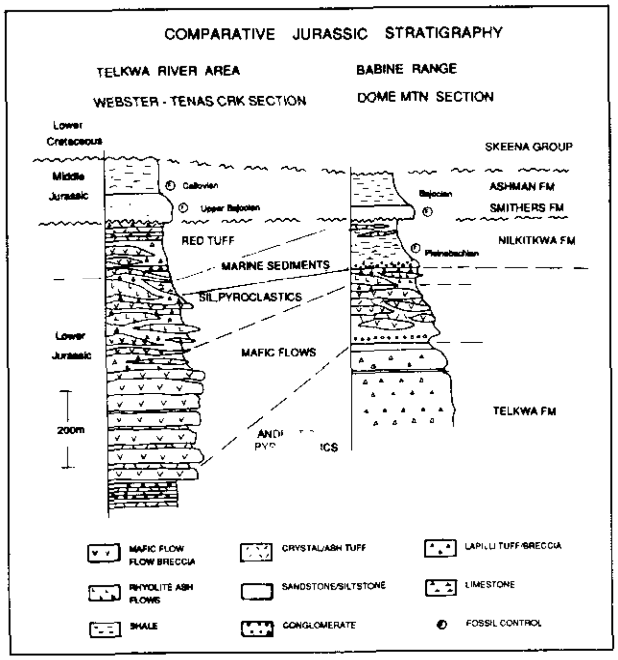

Figure 1-23-4. Comparative Jurassic stratigraphy, Telkwa River and Babine Range.

basal member of a fining-upward sequence of maroon lapilli and crystal tuffs. The tuffs are typical of the lower part of the Telkwa Formation. Below the conglomerate, on the steep north-facing slope of Mount McKendrick, is a thick section of greenstone intruded by leucogranitic lenses. This section is atypical of the Hazelton Group and is believed to be older, perhaps Triassic.

Andesitic Pyroclastic Facies

Maroon to greenish grey feldspathic pyroclastic rocks with minor feldspar-phyric andesite flows underlie the area south of Mount McKendrick (MacIntyre *et al.*, 1987). Fining-upward sequences beginning with volcanic breccia or lapilli tuff and grading upward into thin-bedded crystal and ash tuff are common. These fine-grained tuffs are strongly foliated and tightly folded in places. Beds of maroon to red tuffaceous mudstone, sandstone and pebble conglomerate occur sporadically throughout the section, representing periods of erosion between volcanic cycles.

On Dome Mountain, coarse flow breccias comprised of blocks of feldspar-phyric andesite in a feldspar-rich matrix are common, suggesting proximity to an Early Jurassic eruptive center (MacIntyre, 1985). These coarse breccias are overlain by strongly foliated, thin-bedded maroon to red tuffs. A similar section of thin-bedded tuff and epiclastic rocks underlies a thick section of massive aphyric basalt flows along the southern limit of the Telkwa map sheet and may correlate with rocks in a similar stratigraphic position in the Babine Range.

With the exception of the section described above, the transition from andesitic pyroclastics to overlying basaltic flows and red tuffs is not well exposed in the Telkwa River area. However, Tipper and Richards (1976) describe a measured section from the Loljuh Creek area south of the Telkwa map sheet that we believe transects this contact. The section is shown in Figure 1-23-5. We would place the boundary between the lower andesitic pyroclastic facies and overlying basaltic flow facies at the base of the first amygdaloidal flow.

Basaltic Flow and Red Tuff Facies

Up to 300 metres of aphyric to augite-feldspar-phyric basaltic flows with interbeds of maroon to red crystal and lapilli tuff and related epiclastic rocks underlies the area south of Webster and Tenas creeks. The basaltic flows are fine grained, dark grey to black and relatively unaltered. They are probably basaltic in composition. Flow-top breccia with zeolite cement is common near the top of the section. Locally the flows are amygdaloidal. The flows are resistant and form steep cliff faces along the north side of the northern tributary of Dockrill Creek and in the headwaters of Goathorn, Webster and Tenas creeks. These basaltic flows are correlated with a much thinner section of amygdaloidal flows and red tuffs that overlies andesitic pyroclastic rocks in the Babine Range (Figure 1-23-4). This correlation is based on similar stratigraphic positions.

A medium to thick-bedded unit of interbedded amygdaloidal flows, maroon to grey lapilli and crystal tuff, volcanic breccia, lahar and quartz-feldspar-phyric ash-flow tuff caps the thick section of basaltic flows in the Goathorn – Webster Creek area. A typical section through this unit is shown in Figure 1-23-6. The gradual transition from predominantly massive flows at the base into interbedded flows, tuffs and epiclastics and finally into predominantly red air-fall tuff and tuffaceous mudstone with sporadic amygdaloidal flows, is typical of the basaltic flow/red tuff facies of the Telkwa River area.

Whole-rock chemistry has been completed on a number of samples of basalt from the basalt/red tuff facies of the Telkwa Formation. Unfortunately fresh samples are very difficult to obtain from this unit. Two relatively unaltered samples were collected from the Grouse Mountain area in 1987. The results of these analyses are presented in Table 1-23-2. The samples analyzed had SiO_2 values around 47 per cent and TiO_2 values around 0.80 per cent. Na_2O is variable, ranging from 1.93 to 4.87 per cent; K_2O is relatively low. These analyses suggest the basalts belong to the calcalkaline or subalkaline suite of volcanic rocks. Their chemistry is similar to that of volcanic rocks found in young volcanic island arcs.

Siliceous Pyroclastic Facies

The upper part of the basaltic flow/red tuff facies contains sporadic beds of cream to grey-weathering, quartz-feldspar-phyric ash flow, spherulitic rhyolite and siliceous lapilli tuff. A typical section is exposed north of Winfield Creek (Figure 1-23-7). Toward the Howson Range, along the southeast and easterly borders of the map area, the felsic pyroclastic beds become sufficiently numerous within the section to define a distinct facies. Locally beds of welded ash-flow tuff and ignimbrite occur in this facies and rhyolite domes may also be part of this succession. Well-bedded red tuffs of the

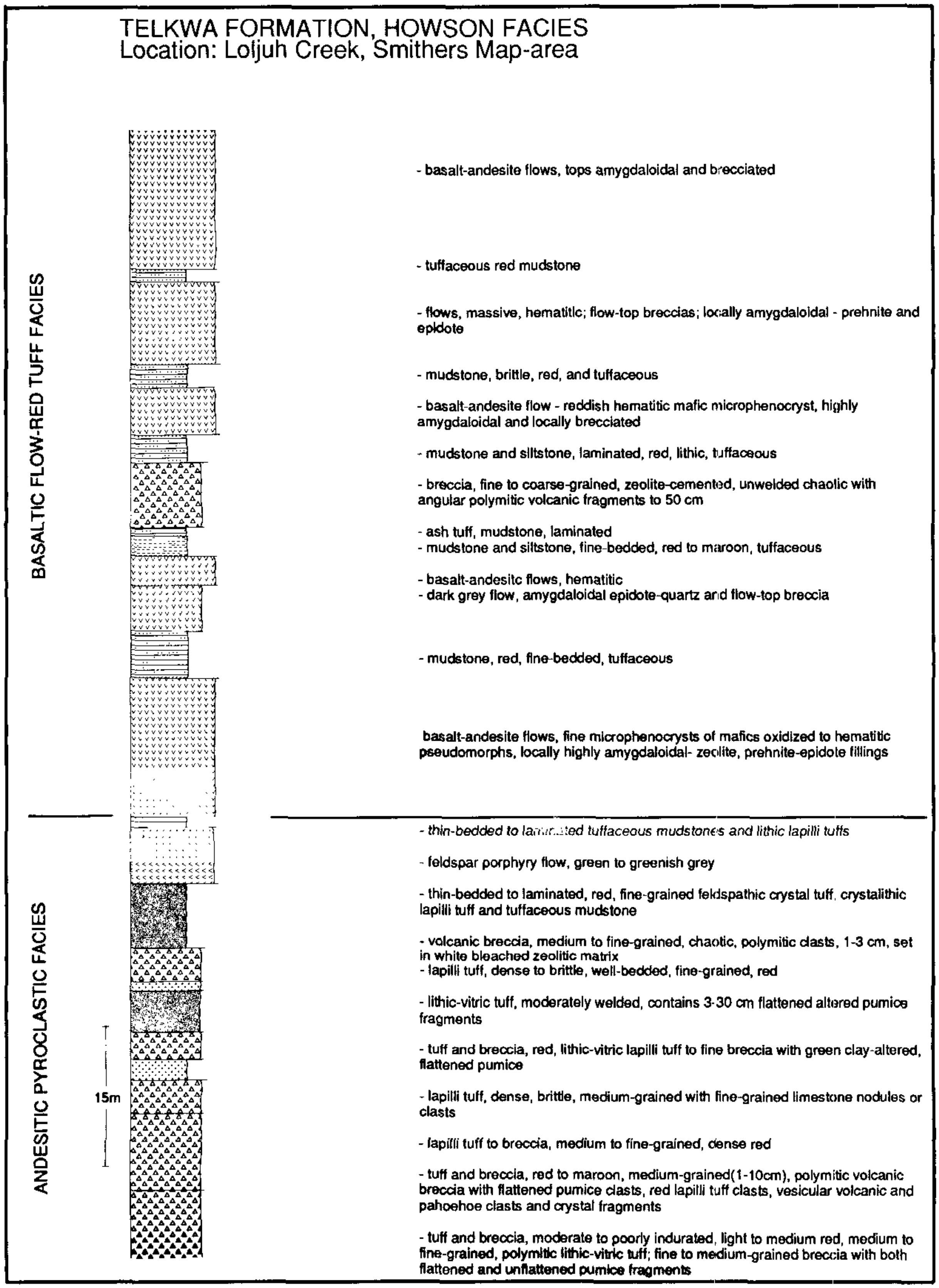

Figure 1-23-5. Stratigraphic section, Loljuh Creek area (modified after Tipper and Richards, 1976).

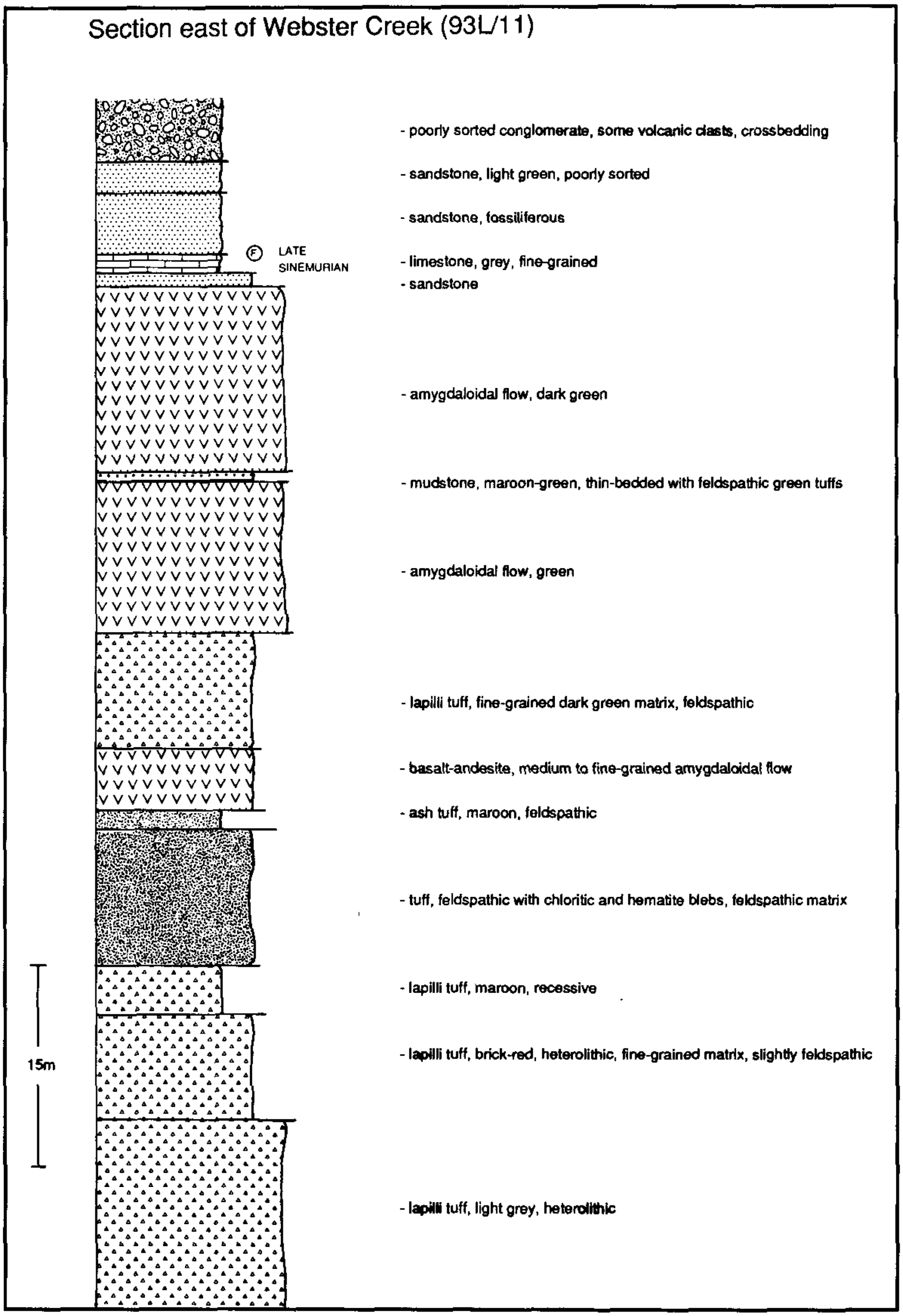

Figure 1-23-6. Stratigraphic section east of Webster Creek. Transition zone between basaltic flow–red tuff facies of Telkwa Formation and overlying Red Tuff member of the Nilkitkwa Formation.

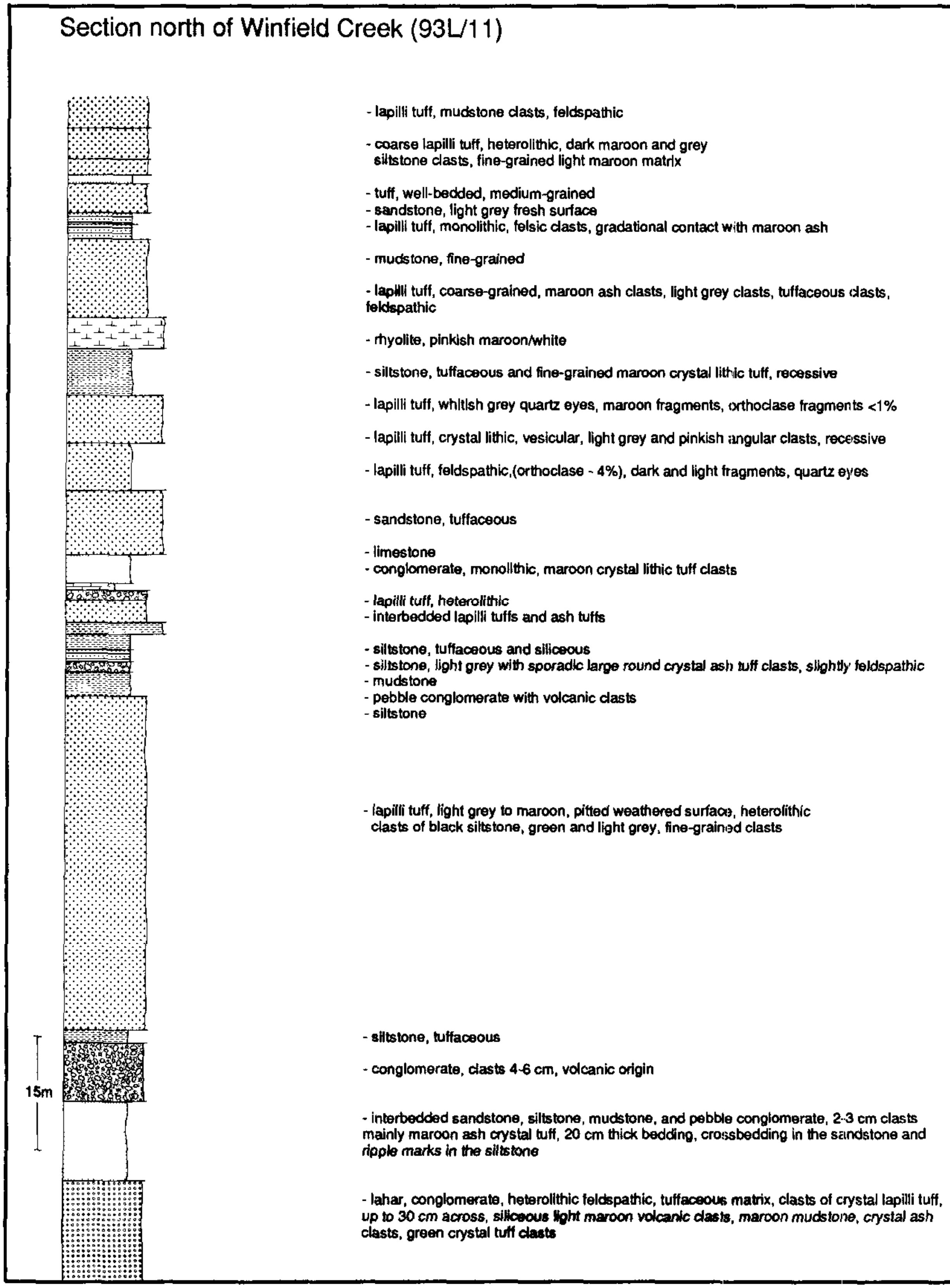

Figure 1-23-7. Section north of Winfield Creek. Transitional into overlying Red Tuff Member of Nilkitkwa Formation.

TABLE 1-23-2

MAJOR OXIDE ANALYSES AND CIPW NORMS, TELKWA FORMATION BASALT, GROUSE MOUNTAIN AREA

Oxide	1	2
SiO_2	47.78	47.48
TiO_2	0.84	0.76
Al_2O_3	16.37	15.58
Fe_2O_3	4.59	2.37
FeO	6.24	7.17
MnO	0.25	0.18
MgO	7.96	7.96
CaO	4.97	9.93
Na_2O	4.87	1.93
K_2O	0.49	0.78
P_2O_5	0.17	0.13
CO_2	0.69	0.14
LOI	4.25	2.73
TOTAL	99.47	97.14

CIPW NORM - Volatile Free		
or	3.06	4.89
ab	43.58	17.32
an	22.61	33.47
di	1.84	14.49
hy	0.77	22.88
ol	19.02	1.47
mt	7.04	3.64
il	1.69	1.53
ap	0.42	0.32
AN=	34.16	65.90

N.B.: All values in per cent.

Sample Descriptions:

1—PDE87-183-1, Lab Number 33905, 646669E,6056106N, basalt, south of Deep Creek.

2—PDE87-250-1, Lab Number 33906, 646403E,6051208N, basalt, north of Grouse Mountain.

Nilkitkwa Formation conformably to disconformably overlie the siliceous pyroclastic rocks. Tipper (1979) describes a similar stratigraphic succession in the Whitesail Lake area. Here the felsic pyroclastics are most likely Early Bajocian in age.

In the Babine Range, the siliceous pyroclastic facies is only locally present. The best exposures are north and south of Burbridge Lake where over 100 metres of cream to grey ignimbrite and spherulitic rhyolite overlies a thick section of amygdaloidal basalt. The siliceous pyroclastic facies is overlain and may in part be interbedded with the Red Tuff member of the Nilkitkwa Formation.

Age of the Telkwa Formation

The age of the volcanic rocks that underlie the Telkwa River area is conjectural due to the lack of fossil control and isotopic dates. However, on the crest of the ridge east of the easternmost tributary of Webster Creek, a well-bedded section of very fossiliferous limestone, sandstone and pebble conglomerate caps a thick section of interbedded amygdaloidal flows and tuffs (Figure 1-23-6; Plate 1-23-1). The sediments contain the pelecypod *Weyla* and are probably Late Sinemurian or Early Pliensbachian in age (GSC Report

Plate 1-23-1. Telkwa Formation sediments overlying amygdaloidal flows and basalts.

No. J11-1988-TPP). The basaltic flows and underlying andesitic pyroclastics are therefore Sinemurian or older. We correlate the sedimentary beds with the Nilkitkwa Formation.

Amygdaloidal flows also crop out on the southeast flank of Dome Mountain and here, as elsewhere, they are overlain by marine sediments of the Nilkitkwa Formation. The sediments contain Early Pliensbachian macrofossils (GSC Report No. J7-1985-HWT). This stratigraphic relationship has also been documented northwest of Round Lake where marine sedimentary strata overlying Telkwa volcanics contain fossils diagnostic of the basal zone of the Early Pleinsbachian (GSC Report No. J4-1987-HWT).

South of the map area, in what is known as the Skeena Arch, the granitic Topley intrusions cut the Telkwa Formation. These intrusions give potassium-argon ages between 195 and 205 Ma. This is further evidence that the Telkwa Formation is Sinemurian or older.

NILKITKWA FORMATION (lJN)

The Nilkitkwa Formation ranges from Early Pliensbachian to Middle Toarcian in age and includes a lower, thin-bedded marine sedimentary facies and an upper red tuff facies with minor basalt flows and felsic ash-flow tuffs (Tipper and Richards, 1976). In the type area of the Nilkitkwa Range the formation is as much as 1000 metres thick but in the Babine Range it is much thinner. West of the Bulkley River the sedimentary facies is very thin or absent, but the overlying Red Tuff member is relatively thick and widespread.

Marine Sedimentary Member

At Dome Mountain, in the Babine Range, marine sedimentary beds containing Early Pliensbachian fossils overlie interbedded basaltic flows and red tuffs of the Telkwa Formation. The sedimentary strata are mapped as part of the Nilkitkwa Formation (Tipper, 1976). The Nilkitkwa section begins with coarse conglomerate beds containing granitic and felsic volcanic clasts, and grades upward into thin-bedded argillite and siltstone. The felsic volcanic clasts are probably derived from the felsic pyroclastic facies of the Telkwa Formation.

Limestone and chert beds occur in the lower part of the section and help distinguish Nilkitkwa rocks from younger, lithologically similar formations. Shallow-water fossiliferous limestone, interbedded with pebble conglomerate and feldspathic sandstone, is particularly common where Nilkitkwa sediments onlap Telkwa volcanics in the Telkwa River area. Here the sediments are close to a Late Sinemurian-Early Pliensbachian strand line.

Sedimentary beds containing Early to Late Pliensbachian fossils (GSC Fossil Report J4-HWT-1987) are also found northwest of Round Lake and are included with the Nilkitkwa Formation. The sedimentary beds are overlain by red tuffs that have been mapped as the Red Tuff member of the Nilkitkwa Formation (Tipper, 1976). To the east of Round Lake, sandstones containing probable Middle Jurassic fauna overlie the red tuffs. This stratigraphic succession is similar to that observed further to the west in the Webster Creek area of the Telkwa Range.

In the Telkwa Range, on the ridge just east of the easternmost tributary of Webster Creek, a section of very fossiliferous well-bedded, shallow-water sandstone, conglomerate and limestone caps a thick section of interbedded amygdaloidal basaltic flows and red to grey tuffs and lahars (Figure 1-23-6). Fossils collected from this locality are Late Sinemurian or Pliensbachian in age (GSC Fossil Report J11-1988-TPP). Although slightly older, these beds have a similar stratigraphic position to the basal beds of the Nilkitkwa Formation on Dome Mountain. If these rocks are correlative then the base of the Nilkitkwa sedimentary sequence is diachronous, younging slightly to the northeast. Slight variations in the age of basal beds of the Nilkitkwa Formation may reflect onlapping of sediments onto a series of volcanic islands as the Nilkitkwa marine transgression progressed.

Above Silvern Lake, on the northwest flank of Hudson Bay Mountain, thin beds of fossiliferous limestone and sandstone overlie amygdaloidal flows and are overlain by the Red Tuff member of the Nilkitkwa Formation. The limy beds have the same stratigraphic position as similar beds at Dome Mountain, Round Lake and east of Webster Creek, and are therefore mapped as part of the Nilkitkwa Formation.

Red Tuff Member

The Red Tuff member of the Nilkitkwa Formation is comprised of medium to thin-bedded red to maroon ash, crystal and lapilli tuff, and related epiclastic rocks with subordinate beds of grey ash-flow tuff and amygdaloidal basalt. Good sections of the member are exposed in the Webster, Tenas and Glacis creeks drainage area and in the area northeast of Winfield Creek (Figure 1-23-7).

In the Telkwa Range, shallow-marine sediments of the Smithers Formation overlie the Red Tuff member of the Nilkitkwa Formation. However, in the Babine Range the Smithers Formation sits directly on the Nilkitkwa marine sediments; the Red Tuff member is apparently absent.

West of Howson Creek a good section of well-bedded red tuffs is exposed along the crest of a northwest-trending ridge. The red tuffs overlie and in part are interfingered with siliceous pyroclastic rocks of the Telkwa Formation. Thin beds of shallow-water, fossiliferous limestone, sandstone and pebble conglomerate locally occur in the zone of transition between these two facies; these sediments, where present, are correlative with the lower marine sedimentary beds of the Nilkitkwa Formation.

In the Tenas Creek area, the red tuffs occur at the top of the volcanic succession and are conformably to disconformably overlain by sandstones of the Smithers Formation. The sandstones contain Late Bajocian ammonites (Sections XIV and XX, Tipper and Richards, 1976). The red tuffs are therefore pre-Late Bajocian in age. Elsewhere in the Smithers area, the Red Tuff member is known to be Toarcian in age (Tipper and Richards, 1976).

In the Winfield Creek area a good section through the Red Tuff member is exposed along the north side of the most southerly ridge. Several eruptive cycles are recognized, each beginning with lapilli tuff and fining upward into red crystal and ash tuff. Some of the cycles begin with a grey ash flow with flattened pumice clasts. The eruptive cycles are locally separated by beds of marl, volcanic sandstone and pebble conglomerate. A typical cycle is shown diagrammatically in Figure 1-23-8.

Smithers Formation (mJS)

The Smithers Formation is a sequence of shallow-water marine sediments containing predominantly Bajocian ammonites and pelecypods. The formation marks the end of volcanism and the beginning of an extensive marine transgression that progressively onlapped volcanic rocks exposed in the Skeena Arch. The transgression continued into early Late Jurassic time.

In the Telkwa River area, the stratigraphic succession appears to be nearly complete, beginning with shallow-marine sediments of the Smithers Formation and grading up-section into finer-grained, deep-water sediments of the Ashman Formation. This stratigraphic sequence is well documented on Ashman Ridge, northwest of the current map area (Tipper and Richards, 1976).

The base of the Smithers Formation is exposed in the Tenas Creek area and on the northwest flank of Hudson Bay Mountain. In both localities the formation appears to be conformable with the underlying Red Tuff member of the Nilkitkwa Formation. The base of the formation is probably diachronous, younging to the south as it onlaps older strata. In the Tenas Creek area the basal beds of the formation contain Late Bajocian ammonite fauna; on Ashman Ridge to the north, beds at a similar stratigraphic position contain Middle Bajocian fauna.

Ashman Formation (muJA)

As mentioned above, the Ashman Formation appears to conformably overlie beds of the Smithers Formation and appears to be part of a continuous fining-upward sedimentary succession. Where the two formations are exposed in a continuous fining-upward sequence, as on Ashman Ridge and in the Tenas Creek area, the contact is defined largely on the age of contained fossils rather than lithological differences. In the study area fauna collected from the Ashman Formation are predominantly Callovian in age, but like the

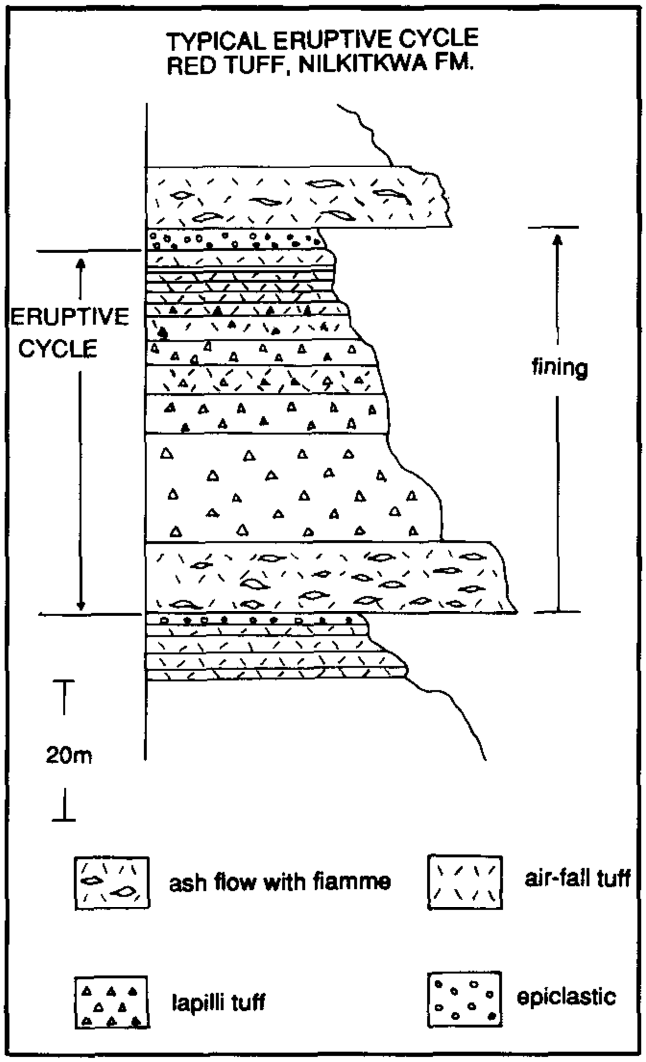

Figure 1-23-8. Typical eruptive cycle, Red Tuff member, Nilkitkwa Formation.

Smithers Formation, the base of the formation is probably diachronous.

In the current study, the boundary between the Ashman and Smithers formations is set where fine-grained clastic sediments predominate over shallow-water sandstones and pebble conglomerates. Using this lithostratigraphic definition, the Ashman Formation is predominantly well-bedded, fine-grained dark grey siltstone and black shale. Quartzose sandstone and pebble conglomerate beds occur sparsely within the succession. The Ashman Formation is a moderate to deep-water turbidite sequence that was deposited during a major Middle Jurassic marine transgression. This marine transgression began with deposition of the shallow-water, near-shore Smithers Formation.

Tipper and Richards (1976) include the Ashman Formation with the Middle to Late Jurassic Bowser Lake Group whereas the Smithers Formation is included with the Hazelton Group. The group boundary occurs within a fining-upward sedimentary sequence that may represent a continuous stratigraphic section ranging from Bajocian to Callovian. If this is true then the Smithers and Ashman formations should be in the same group. In the study area the two formations are included as part of the Hazelton Group; Bowser Lake rocks are restricted to fluvial and deltaic facies that reflect a Middle to Late Jurassic marine regression and regional uplift.

BOWSER LAKE GROUP

The Bowser Lake Group includes marine and nonmarine successor-basin sediments and minor volcanics ranging from Late Bajocian to Kimmeridgian in age. The sediments were deposited in the Bowser Basin, north of the study area. The Skeena Arch formed the southern limit of the basin. A Middle Jurassic marine transgression was followed by uplift of the Skeena Arch and shedding of coarse detritus northward into a shrinking Bowser Basin.

TROUT CREEK ASSEMBLAGE (uJTC)

Coarse-grained, poorly sorted chert-pebble conglomerates, sandstones and siltstones of the alluvial-deltaic, coarsening-upward Trout Creek assemblage disconformably to conformably overlie the Ashman Formation. The Trout Creek assemblage is Late Oxfordian to Early Kimmeridgian in age and represents the start of uplift of the Skeena Arch and concomitant shedding of coarse detritus northward into the Bowser Basin as prograding deltaic fans. The base of the Trout Creek assemblage is diachronous, younging northward into the basin.

The only rocks mapped as part of the Trout Creek assemblage within the map area are the coarse conglomerates in the type area near Trout Creek (Tipper, 1976).

POST-JURASSIC ROCKS

Early Cretaceous Skeena and Sustut successor basin deposits, and Middle Cretaceous to Eocene Kasalka and Ootsa Group continental volcanics unconformably overlie Hazelton and Bowser Lake Group rocks. The Cretaceous Bulkley intrusions and the Tertiary Babine intrusions cut the Jurassic rocks and are the source of most of the mineral occurrences in the area. The post-Jurassic rocks have been described in previous reports (MacIntyre *et al.*, 1987; MacIntyre and Desjardins, 1988) and are beyond the scope of this paper.

STRUCTURAL STYLE

Jurassic rocks in the Telkwa River area are exposed as a series of tilted fault blocks. In general the beds are not folded and very little penetrative cleavage was observed. The volcanic members are often quite fresh with little or no alteration. This is in contrast to the chlorite-epidote-altered Jurassic rocks of the Babine Range which have been folded and have a well-developed penetrative foliation. It is not clear why there is such a difference in structural style between the two ranges.

DISCUSSION

The Telkwa stratigraphic succession indicates that Early Jurassic volcanism began with eruption of predominantly andesitic pyroclastic material, probably from numerous vents located south of the map area. This was followed by a short hiatus and erosion of the volcanic pile prior to widespread outpouring of basaltic lava and deposition of red airfall tuff. Late in this volcanic cycle, siliceous ash flows and rhyolite were erupted from volcanic centres located south and west of the map area. Early Jurassic plutons are exhumed along the axis of the Skeena Arch and in the Howson Ranges. These plutons probably formed at depth beneath major early Jurassic eruptive centres.

Three volcanic-sedimentary cycles are recognized in the Early to Middle Jurassic stratigraphic succession. At the base is a lower andesitic pyroclastic section that grades up into a very thin (or absent) marine to nonmarine sedimentary member containing Sinemurian fossils. This is overlain by a second volcanic-sedimentary cycle that begins with a bimodal volcanic sequence that includes thick accumulations of subaerial amygdaloidal basalt and interbedded red tuff and epiclastics, and local accumulations of siliceous pyroclastics and rhyolite flows. Marine sedimentary strata of the the Late Sinemurian to Pliensbachian Nilkitkwa Formation onlap this volcanic succession. The final volcanic-sedimentary cycle begins with subaerial red tuff and felsic pyroclastics of the Nilkitkwa Formation which is onlapped by marine sediments of the Smithers and Ashman formations.

Each volcanic-sedimentary cycle is separated by a disconformity. Sedimentary members onlap and are interfingered with volcanic members and typically fine upward into progressively deeper water facies, that is, they represent marine transgressions. The sedimentary members may be absent where uplift and erosion has occurred prior to the next volcanic cycle. Each volcanic cycle is distinguished by compositional and lithological differences and therefore mapped as a separate volcanic facies.

MINERAL DEPOSITS

As discussed in a previous report (MacIntyre *et al.*, 1987), mineral deposits in the Smithers area can be subdivided into four groups. These are: (1) mesothermal and epithermal gold-silver-bearing quartz veins; (2) copper-silver veins and pods in mafic volcanic rocks; (3) copper-zinc-silver massive sulphide deposits associated with bimodal submarine volcanics; and, (4) porphyry copper-molybdenum deposits associated with quartz monzonite to granodiorite intrusions.

The showings in the Telkwa River area are mostly Type 2 – copper-silver veins and pods in mafic volcanic rocks. These showings may in part be associated with porphyry copper mineralization at depth. Showings on Hudson Bay Mountain are most likely related to the large porphyry copper-molybdenum system within the core of the mountain.

The preferred host rocks for copper-silver occurrences, as elsewhere in the map area, are the amygdaloidal basalt flows of the upper Telkwa Formation. Intense epidote-calcite-chlorite alteration is often associated with this type of occurrence. There is no obvious control to their distribution, although occurrences in the Webster and Cabinet Creek areas are near a granodioritic intrusion.

WEBSTER CREEK – CABINET CREEK AREA

In the headwaters of Webster creek, a large stock of granodiorite of probable Late Cretaceous age intrudes basaltic flows of the upper Telkwa Formation. A zone of disseminated pyrite and magnetite with associated propylitic alteration is superimposed on hornfelsed volcanic rocks surrounding the stock. A stockwork vein system containing pyrite, minor chalcopyrite and molybdenite is locally present within the pyrite-magnetite zone.

High-grade pods of pyrite, chalcopyrite, and magnetite in a gangue of altered country rock, quartz, and epidote, occur locally along flow contacts in the area north of the stock. The strongest mineralization appears to be near dyke contacts. Also present are calcite and quartz stringers that carry malachite, bornite, chalcopyrite, azurite, chalcocite, tetrahedrite, hematite and minor disseminated specularite. These showings crosscut faults and shears in dark green to maroon basalt of the Telkwa Formation.

In the Cabinet Creek area, quartz veins and isolated pods containing high-grade concentrations of chalcopyrite, bornite and tetrahedrite with minor specularite and galena, cut basaltic flows of the Telkwa Formation.

WINFIELD CREEK AREA

In the Winfield Creek area chalcocite, chalcopyrite and bornite occur as veinlets and amygdule fillings in basaltic flows, crystal and lithic tuffs and siliceous ash flows. Here the showings appear to be related to a fault zone that trends 130 degrees and dips 75 degrees south.

HUDSON BAY MOUNTAIN

Numerous high-grade zinc-lead-silver veins occur in the area peripheral to the Glacier Gulch porphyry molybdenum deposits. This area was mapped by R.V. Kirkham from 1963 to 1968. His data is currently being recompiled in preparation for publication.

SUMMARY

The major conclusions from fieldwork completed in 1988 are:

(1) Mafic flows, felsic pyroclastics and red tuffs in the Telkwa River area correlate with a similar but much thinner section in the Babine Range. These rocks, previously mapped as Nilkitkwa Formation in the Babine Range, are now included as an upper division of the Early Jurassic Telkwa Formation.

(2) The thinning of volcanic members and the corresponding thickening of marine sedimentary members of both the Telkwa and Nilkitkwa formations to the northeast suggests a change from subaerial to submarine facies in this direction during Late Sinemurian to Early Pliensbachian time.

(3) The Telkwa Formation is divisible into four facies in the map area. These facies are characterized by their predominant lithologies. In ascending stratigraphic order they are heterolithic basal conglomerate; andesitic pyroclastics; basaltic flows and red tuffs and; siliceous pyroclastics and rhyolite flows. The overlying Nilkitkwa Formation includes a lower marine sedimentary member and an upper red tuff member.

(4) The Early Jurassic volcanics of the Telkwa River area are relatively undeformed and unaltered compared to similar rocks in the Babine Range. Vertical tectonics rather than folding and thrust faulting are the predominate structural style.

(5) Vein and disseminated mineralization in the Hudson Bay Mountain – Telkwa River area is related to hydrothermal systems generated by emplacement of porphyritic intrusions in Late Cretaceous and early Tertiary time.

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