STRATIGRAPHIC AND STRUCTURAL SETTING OF THE SHASTA SILVER-GOLD DEPOSIT, NORTH-CENTRAL BRITISH COLUMBIA (94E)

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INTRODUCTION

The Shasta silver-gold stockwork deposit (Figure 2-5-1) is situated in north-central British Columbia, approximately 300 kilometres north of Smithers. The property is accessed by a four-wheel-drive road from the Sturdee airstrip, 9 kilometres west of the property, or from Fort St. John via the Omineca mining road and the newly constructed Cheni mine road, however, road use is currently being restricted by Cheni Gold Mines Inc.

The objective of this study is to define the stratigraphy, structure and geologic environment of the deposit. It should result in an understanding of the relationship between volcanism, brittle deformation and hydrothermal activity in the Toodoggone precious metal camp. The research is part of a 2-year mapping and research project that is the basis of an M.Sc. thesis at Carleton University.

Fieldwork, conducted between June 2 and August 30, 1988, consisted of geologic mapping and the examination of drill core and surface trenches. Mapping was conducted at two scales; 1:10 000 property mapping on an orthophoto base supplied by Esso Minerals Canada, and 1:1000 mapping on a contour map prepared from earlier orthophoto coverage. Samples were collected for age determinations, whole-rock analysis and petrographic study.

HISTORY

The Shasta deposit was discovered in 1972 when W. Meyers and Associates carried out surface exploration on ground staked for Shasta Mines and Oil Ltd. (now International Shasta Inc.) that led to the Main (Rainier) zone discovery. In 1973 the property was optioned by Newmont Exploration of Canada Limited and by the end of 1984 extensive geochemical and geophysical surveys, some surface mapping, hand trenching and 2700 metres of diamond drilling had been completed. This work defined the newly discovered Creek zone, indicated precious metal mineralization in the Jock and Rainier zones and intersected the JM zone. Reserves were estimated at 2.4 million tonnes of 2.7 grams gold-equivalent per tonne (47 g Ag = 1 g Au) or 0.7 million tonnes of 5.0 grams gold-equivalent per tonne.

Esso Minerals Canada optioned the property in 1987 and immediately started an extensive program of geochemical and geophysical exploration, surface mapping, backhoe trenching and diamond drilling.

Follow-up trenching and diamond drilling on geochemical and electromagnetic (VLF) and resistivity anomalies led to the discovery of the JM (Just Missed) zone. This exploration program continued in 1988; over 4000 metres of diamond drilling, and surface exploration work, have defined the JM zone over 800 metres, extended the Rainier vein, tested the newly discovered Cayley vein and two other new discoveries, the O zone and the Baker zone. Mineralization found on surface within a strong resistivity anomaly (East zone) has not been tested by drilling.

REGIONAL SETTING

The project area lies within the Stikine terrane along the eastern margin of the Intermontane Belt of the Canadian

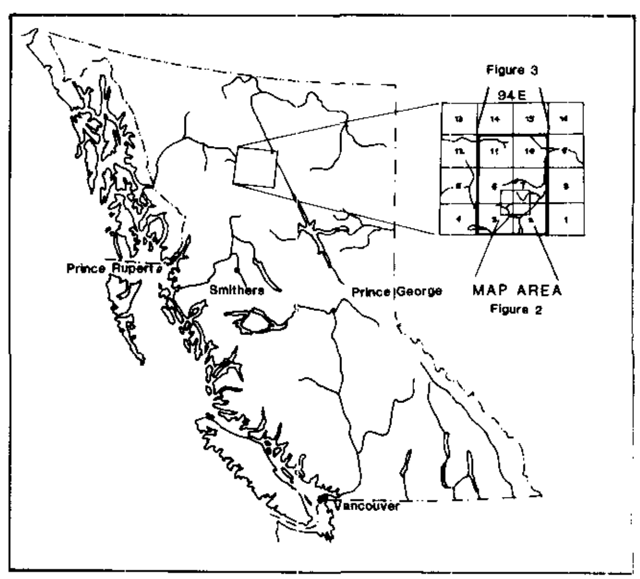

Figure 2-5-1. Location map.

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

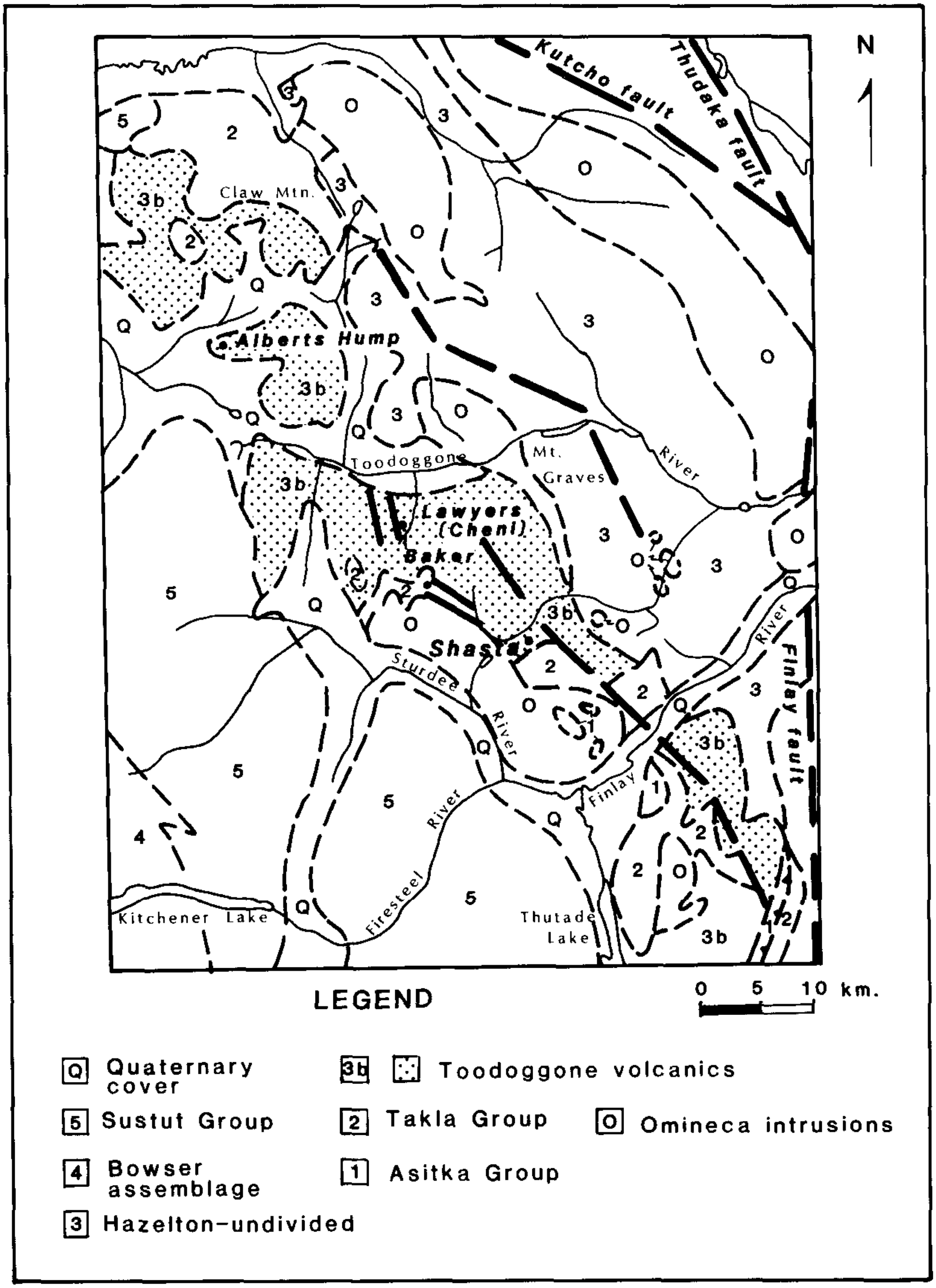

Figure 2-5-2. Regional setting.

Cordillera. Stikinia is an allochthonous terrane composed predominantly of Paleozoic Asitka Group sedimentary rocks, mafic volcanics of the correlative Takla and Stuhini groups, Lower to Middle Jurassic volcanic and sedimentary rocks of the Hazelton Group, the coeval Omineca intrusions and clastic sediments of the Middle to Upper Jurassic Bowser assemblage and the Cretaceous Sustut Group. Paleontologic and paleomagnetic evidence, combined with reconstructions of correlative terranes, suggest that terranes east of the northern Rocky Mountain Trench may have been displaced northwards relative to the North American craton by as much as 1300 kilometres (Gabrielse, 1985).

The oldest rocks exposed in the area are Permian limestones and minor clastic sediments of the Asitka Group, commonly overthrust on Upper Triassic rocks or occurring as pendants within the Omineca intrusions. The Upper Triassic Takla Group consists predominantly of mafic, alkaline to subalkaline volcanics, associated epiclastic and minor shallow-marine sedimentary rocks. The volcanics are mainly submarine with some subaerial facies, suggesting locally emergent volcanic edifices.

Unconformably overlying the Takla Group are Jurassic Hazelton Group volcanic and associated sedimentary rocks. The unconformity has been noted in several localities; the base of the Hazelton Group consists of either polymictic conglomerate carrying chert and limestone clasts (Monger and Church, 1977; Mihalynuk and Ghent, 1986; Thorkelson, 1988) or conglomerate with abundant, equigranular intrusive clasts (Diakow, 1985). Tipper and Richards (1976) defined the stratigraphy flanking the south and west margins of the Bowser Basin as Hazelton Group, an island arc sequence of volcanics and sediments deposited in the Hazelton trough between Sinemurian and Lower Callovian time. They further divided the Hazelton into three formations and five geographically restricted facies; the most extensive formation being the Sinemurian to Lower Pliensbachian Telkwa Formation. Since that time correlative volcanic rocks have been recognized along the east and northeast margins of the Bowser Basin: the Toodoggone volcanics (Diakow *et al.*, 1985) and the Coldfish volcanics (Thorkelson, 1988) respectively. Diakow is currently completing a Ph.D. thesis study on the Toodoggone volcanics and will propose them as a distinct formation within the Hazelton Group (personal communication, 1988).

The Hazelton volcanics, in the Toodoggone area, have been traditionally divided into the quartz-bearing Toodoggone volcanics and undivided Hazelton volcanics lacking visible quartz, following the lead of Carter (1972) and Gabrielse (1976). More recent work by Diakow (1983, 1985), Diakow *et al.* (1985), Panteleyev (1982, 1984) and Schroeter (1982) defined the Toodoggone volcanics as a predominantly calcalkaline, felsic, subaerial volcanic succession spanning an age range between 204 and 182 Ma. The sequence includes a middle member of intermediate composition that has yielded ages between 197 and 200 Ma. These rocks may be similar to the undivided Hazelton volcanics exposed further east. The youngest part of the Toodoggone pile is the Saunders grey dacite, a distinctive welded tuff, suggested by Clark and Williams-Jones (1987) to represent a single volcanic episode (Phase 2), 182 to 179 Ma old, that is separated from the rest of the Toodoggone activity (Phase 1) by a hiatus that coincided with the end of significant gold mineralizing events.

The Toodoggone volcanics are bounded to the east by coeval, undivided Hazelton Group volcanics and the Omineca intrusions which are in turn bounded by the Finlay and Thudaka faults, major right-lateral strike-slip faults that mark the eastern boundary of the Intermontane Belt (Figure 2-5-2). To the south and southeast the Toodoggone sequence is in fault contact with, and in places unconformably overlies, Upper Triassic rocks of the Takla Group. The Triassic rocks are best exposed where they are uplifted around the margins of the Black Lake stock. To the north and northwest the Toodoggone volcanics are buried beneath mid-Jurassic to Cretaceous sedimentary rocks of the Bowser assemblage and Sustut Group.

LOCAL GEOLOGY

The Shasta deposit is hosted by a succession of predominantly quartz, biotite, hornblende and feldspar-phyric pyroclastic and epiclastic rocks with some intercalated flows. They were mapped by Diakow *et al.* (1985) as the Toodoggone crystal ash tuffs or Attycelley tuffs and a sample from similar rocks near the Lawyers deposit (Figure 2-5-2) gave a hornblende potassium-argon date of 186 ± 6 Ma. Holbek and Thiersch (1987) established a preliminary detailed stratigraphy for the Shasta property. Figure 2-5-4 is a stratigraphic column based on their work and more extensive mapping done during 1988.

Rocks exposed beneath the Saunders grey dacite west of the Saunders fault (Figure 2-5-3) are different from those to the east, suggesting considerable displacement prior to the emplacement of the Saunders dacite.

TAKLA GROUP

1A, B. AUGITE-PLAGIOCLASE PORPHYRY AND ASSOCIATED SEDIMENTS

The oldest rocks in the study area are pyroxene-plagioclase porphyry flows and breccias of the Upper Triassic Takla Group. The porphyritic volcanics form a thick succession of pillow basalts and volcanic breccias with poorly defined amygdaloidal and porphyritic clasts, and local amygdaloidal to scoriaceous flows. Some subvolcanic rocks are "flower porphyries" with glomeroporphyritic plagioclase. The volcanic breccias locally carry accidental limestone clasts that contain pyroxene crystal detritus. The section mapped includes 110 metres of purple and green to varicoloured volcanic conglomerate, composed entirely of Takla clasts, with interbedded green to dark grey volcanic siltstone and sandstone. These rocks are sandwiched between porphyritic Takla flows and are cut by an extremely coarse feldspar-pyroxene porphyry dyke.

1C, D. MONOMICTIC VOLCANIC CONGLOMERATE

A distinctive maroon to green (colour depends on degree of carbonate-chlorite alteration) monomictic volcanic conglomerate, consisting almost entirely of fine-grained, crowded pyroxene (or hornblende) porphyry cobbles, locally

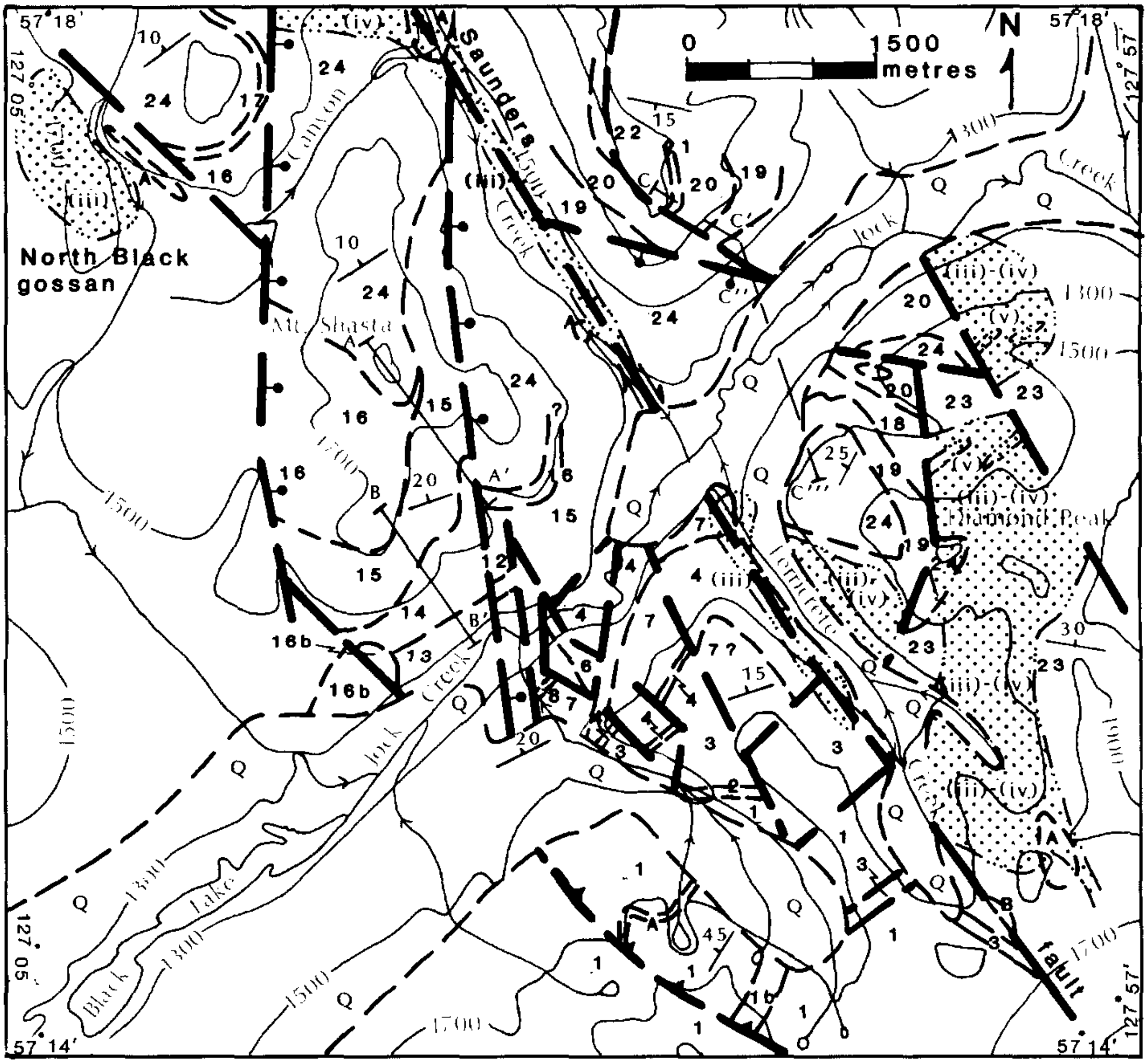

Figure 2-5-3. Local geology.

rests on a finer grained, more heterolithic purple volcanic conglomerate containing red-brown amygdaloidal clasts and rare fossilized wood fragments. These rocks are tentatively assigned to the Takla Group, but have only been observed in fault contact with both Toodoggone and Takla rocks.

The intimate association between subaerial and submarine facies suggests the Takla was extruded in a locally emergent environment.

TOODOGGONE VOLCANICS WEST OF SAUNDERS FAULT

2. Heterolithic Conglomerate With Intrusive Clasts

Between the Toodoggone and Takla volcanics is a transitional unit 30 metres thick that consists of a heterolithic conglomerate containing subrounded Takla clasts and granitic pebbles to cobbles, overlain by a dark purple to green angular volcanic conglomerate that is composed entirely of Takla clasts. Presumably this deposit marks an episode of uplift and erosion related to the onset of Jurassic volcanism.

3a, b. Green and Purple Tuffs, Volcanic Siltstone, Sandstone and Conglomerate

The oldest quartz-bearing unit is a very heterogeneous sequence of thinly bedded volcanic and epiclastic sedimentary rocks, 50 to 100 metres thick, that is well exposed in bluffs on the east side of Paradise Creek (Figures 2-5-3 and 2-5-6). The unit is divided into a green welded chloritic lapilli tuff with interstratified epiclastics, and a purple to purple and

LEGEND FOR FIGURES 2-5-3, 4, 5 AND 6

ALTERATION

(i) Propylitic alteration
(ii) Carbonate-chlorite
(iii) Chlorite-sericite-pyrite
(iv) Quartz-sericite-pyrite with some strong silicification
(v) Advanced argillic alteration
(vi) Potassic alteration

INTRUSIVE ROCKS

A Biotite-hornblende-feldspar porphyry
B Fine-grained equigranular intrusive

STRATIFIED ROCKS

Q Glacial sediments, no drill-hole or trench information

Toodoggone volcanics

24 Saunders grey dacite; welded tuff
23 Feldspathic welded tuff
22 Pyroxene porphyry flows and volcanic mudstone
21 Purple and green thin-bedded epiclastic rocks
20 Purple lapilli tuff
19a,b Heterolithic green lapilli tuff, crystal tuff
18 Monomictic hornblende-feldspar volcanic breccia
17 Brown lapilli tuff
16a,b Hornblende-feldspar porphyry flow, intrusive
15 Hornblende-feldspar-phyric volcanic breccia and spherulitic tuff
14 Laminated crystal tuff
13 Coarse laharic breccia and volcanic sandstone and conglomerate
12 Welded chloritic lapilli tuff
11 Green and purple laharic breccia, sandstone and siltstone
10 Red-rimmed volcanic conglomerate
9 Purple and green volcanic conglomerate
8 Brown volcanic sandstone and conglomerate
7a,b Heterolithic lapilli tuff and volcanic conglomerate, volcanic sediments
6 Quartz-feldspar lapilli tuff
5 Volcanic siltstone and carbonaceous tuff
4,4b Quartz-biotite-feldspar porphyry, associated epiclastic rocks
3a,b Green, purple tuffs and epiclastic rocks
2 Heterolithic conglomerate with intrusive clasts

Takla Group

1c,d Monomictic volcanic conglomerate and purple volcanic conglomerate
1a,b Augite-plagioclase porphyry and associated sedimentary rocks

green welded lapilli tuff with interbedded volcanic siltstone. The green welded tuff has a characteristic foliated appearance with recessive highly flattened chloritic lapilli, fine white to pink feldspar crystals, biotite and quartz. The interbedded epiclastic rocks are similar but the clasts are slightly rounded and the section includes fine-grained crystal-rich sandstones. The purple to purple and green tuff contains flattened clasts within a purple matrix; coarse epiclastics are rare and welded tuffs and volcanic siltstone form most of the section. Both subunits are very thin bedded and rapid lateral facies variations are the rule; they occur in varying proportions and probably represent lateral rather than vertical facies equivalents.

4A, B, C. QUARTZ-BIOTITE-FELDSPAR PORPHYRY FLOW AND EPICLASTICS

Previously described as a crystal tuff, this unit occurs only in the central part of the map area (Figure 2-5-2 and 2-5-3). It is a 70 to 100-metre-thick orange-brown weathering, locally layered, green, subcrowded quartz-biotite-feldspar porphyry. The pink feldspar and chloritized biotite crystals are euhedral to subhedral and the layering is locally highly contorted. Near the Rainier zone (Figure 2-5-6) fragmental rocks, dominated by clasts very similar to the porphyry, are exposed in the same stratigraphic position and are tentatively interpreted as an epiclastic facies equivalent. Lithologies similar to the porphyry, but variably purple and containing hornblende phenocrysts and white feldspars, are exposed on the south side of Ferricrete Creek (Figure 2-5-3) and are interpreted as a facies variant, but may simply be less altered porphyry.

5. GREEN VOLCANIC SILTSTONE AND DARK CARBONACEOUS TUFF

This a very thin unit (1 to 2 metres) that is rarely exposed on surface but occurs in several drill holes and is genetically significant. Lying on top of the felsic porphyry, it consists of highly contorted dark green siltstone that is overlain by and mixed with a dark green to black lapilli tuff containing abundant carbonized wood fragments. This suggests a temporary hiatus after deposition of the porphyry, during which fine sediments accumulated. Vegetation on these sediments was roasted by and incorporated into the base of the ensuing pyroclastic deposit to result in a dark carbonaceous tuff.

6. QUARTZ-FELDSPAR LAPILLI TUFF

This is a distinctive orange-brown weathering unit 90 metres thick, well exposed in the central part of the property. Recessive weathering, moderately flattened chloritic lapilli with crowded quartz and pink feldspar crystals are supported by a green crystal-rich matrix. Accessory clasts include brown, subrounded quartz-feldspar porphyry clasts and small red lithics. In one drill hole a section at the base of this unit consists mostly of altered orange-brown clasts similar to the porphyry in Unit 4.

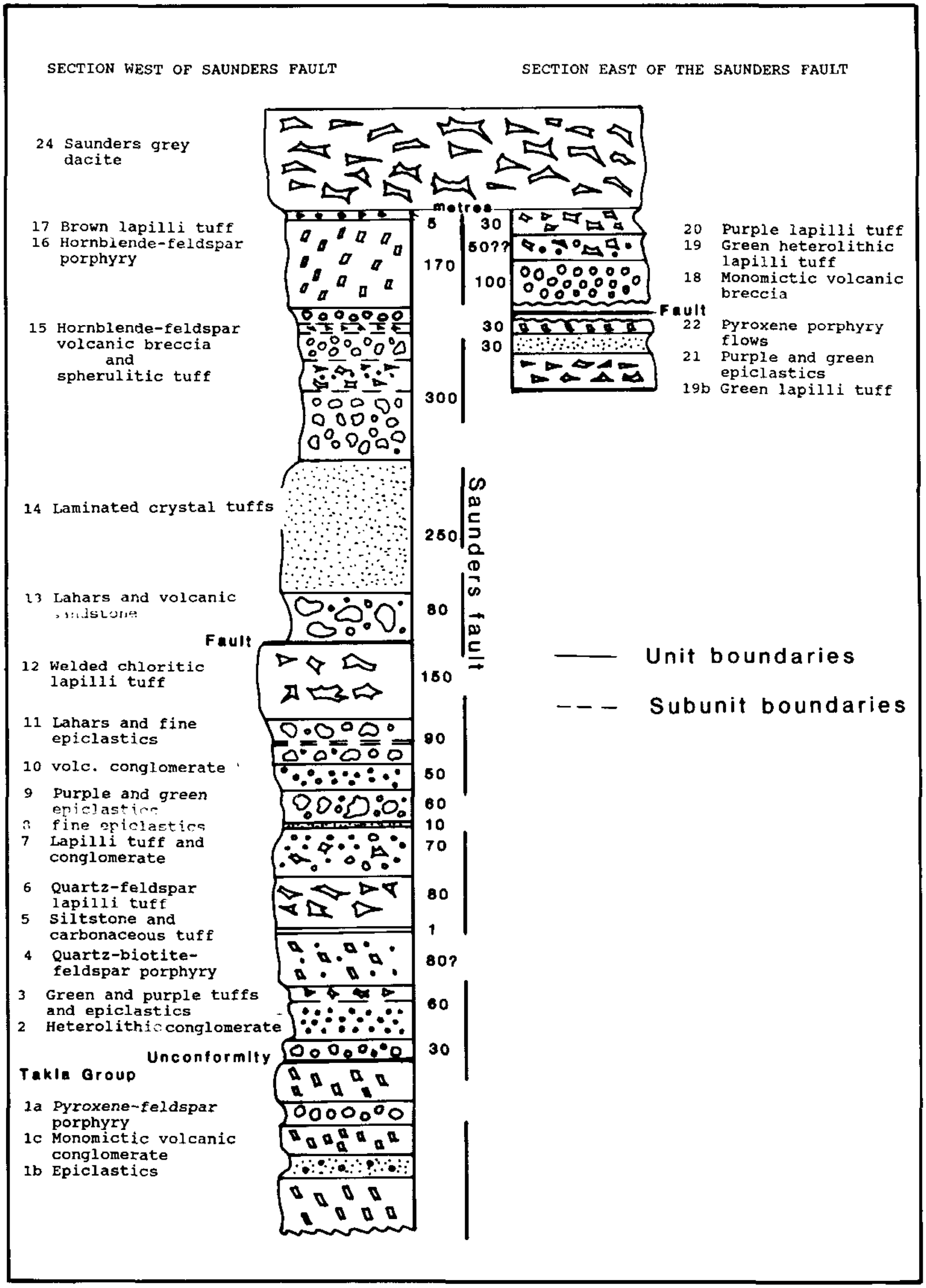

Figure 2-5-4. Stratigraphic column (to scale).

7. Heterolithic Quartz-Feldspar Lapilli Tuff and Volcanic Conglomerate

Immediately overlying Unit 6 is a 50 to 70-metre-thick unit superficially similar to Unit 6. However, flattened clasts lack pointed and cuspate ends and there are more accessory clasts, especially fine-laminated, pyritic, green siltstone clasts and fine red lithic clasts. The section consists predominantly of reworked pyroclastic rocks with at least two thin, welded pyroclastic units.

Overlying the fine heterolithic unit are purely epiclastic biotite and quartz-bearing lithologies that have been divided into several units (8, 9, 10, 11) on the basis of drill-core data.

8. Brown Volcanic Sandstone and Conglomerate

The change to a predominantly sedimentary regime is marked by a 10-metre-thick succession of brown and green, thin-bedded volcanic conglomerate and very thin beds of graded, crystal sandstone and siltstone deposits. There are two fairly distinctive beds within the section: one is a very fine-grained purple siltstone or ash tuff and the other is a dark green fine-grained unit with sparse, tiny chloritic fragments. Quartz, biotite and white to pink feldspar crystals are present throughout the section and some homogeneous beds superficially resemble the porphyry (Unit 4).

9. Purple and Green Volcanic Conglomerate

Comprising fine to coarse volcanic conglomerate, this 60-metre-thick section is characterized by pale green porphyritic fragments in a purple matrix. The rest of the section consists of green to dark maroon, coarse, heterolithic debris flows. Much of this unit is moderately hematized, either pervasively or along fractures. Several thin interbeds of graded purple siltstone to sandstone are present low in the section.

10. Red-Rimmed Volcanic Conglomerate

This distinctive 50-metre-thick unit is a grey-green, poorly sorted volcanic conglomerate with heterolithic subangular to subrounded pebbles, each coated with a hematitic rind. These clasts are resistant and their brick-red surfaces protrude from weathered outcrops. A purple-brown interbed, 2 metres thick, with identical clasts was noted in some sections.

11. Green and Purple Laharic Breccia, Sandstone and Siltstone

Coarse, very poorly sorted laharic deposits containing pebbles and boulders of varied porphyry units, locally with hematitic rinds, are interbedded with graded, crossbedded siltstone to sandstone layers. The 90-metre section is further divided into a green subunit at the base, a very similar middle purple section and an upper green subunit that is identical to the basal part of the section except that it contains numerous boulders of a green foliated welded tuff that looks like pyroclastic interbeds where intersected by drilling. This section consists of numerous small debris-flow deposits locally reworked by small streams.

12. Welded Chloritic Lapilli Tuff

A green-weathering pyroclastic deposit is characterized by strongly flattened recessive quartz and feldspar-phyric lapilli and small chloritic fiammé that impart a foliated appearance to weathered outcrops. Two other clast types are commonly present; angular, brown quartz-feldspar porphyry blocks and flattened, purple, collapsed pumice clasts.

Above the welded tuff the section is truncated by a major northeasterly striking fault and no stratigraphic overlap was observed on either side of the fault. Some stratigraphy is undoubtedly missing from the section but it is not clear how much.

13. Coarse Laharic Breccia and Volcanic Sandstone and Conglomerate

The next unit observed consists of over 80 metres of coarse, very poorly sorted laharic deposits and volcanic sandstone to pebble conglomerate. The laharic deposits are thick bedded and the coarser clasts are all either grey to purple quartz-biotite-hornblende-feldspar porphyry or angular clasts of a green, foliated, welded tuff. The finer sedimentary rocks are dark green sandstone, pebbly sandstone and conglomerate, composed of quartz, biotite and feldspar crystals and heterolithic pebbles, some with hematitic rims.

In two localities a green chloritic tuff with highly contorted purple ash partings was noted at the top of the epiclastics.

14. Laminated Crystal Tuffs

The epiclastic rocks are directly overlain by 250 metres of grey to purple, platy fracturing, thinly laminated quartz, biotite, hornblende and feldspar-bearing crystal tuffs. Near the base this unit is not clearly laminated and resembles a porphyry. The laminations vary from less than a centimetre to 2 centimetres thick and are only obvious on weathered surfaces. Some exposures are cut by narrow, vertical, sandy clastic dykes.

15a, b. Hornblende and Feldspar-Phyric Volcanic Breccia and Spherulitic Lapilli Tuff

The next unit is a thick section that consists of two distinct interbedded rock types. The section is dominated by green to maroon to red-brown hornblende-biotite-feldspar-phyric volcanic breccia. This contains prominent black hornblende needles and is typically fragmental with bomb-sized clasts that lack chilled margins or welded textures. To the north the unit is clearly epiclastic with thin crosslaminated clastic interbeds, whereas to the south it is more massive. The section contains at least two pyroclastic interbeds (15b), consisting of small green chloritic fiammé, collapsed, chloritic, feldspar-phyric lapilli, and rare blocks of hornblende-feldspar porphyry. In three localities the pyroclastic deposits include coarse bombs of porphyry with chilled and cracked margins and spheres 1 to 4 centimetres in diameter, that sometimes impinge on each other along flat faces. These are interpreted as spherulites; they commonly weather in relief giving the outcrop a very distinctive appearance.

16A, B. Hornblende-Feldspar Porphyry Flow

Overlying the volcanic breccias of Unit 15 is a brown to maroon, massive hornblende-biotite-feldspar porphyry flow that is mineralogically and texturally similar to the clasts in the underlying breccia. An intrusive with similar features is exposed near Black Lake.

17A, B. Brown Lapilli Tuff

The flow is overlain by a very thin but laterally continuous, distinctive brown-weathering heterolithic lapilli tuff. On the north face of Black Mountain (Figure 2-5-3) there are 30 metres of thin-bedded green, black and maroon fine-laminated siltstones, sandstones and volcanic pebble conglomerate between the brown tuff and porphyry flow unit.

The brown tuff is overlain by the Saunders grey dacite (*see* below). East of the Saunders fault (Figure 2-5-4) the units exposed beneath the Saunders grey dacite are completely different from those described above. Diakow *et al.*, (1985) mapped these rocks as the Lawyers quartzose andesite and interpreted them to be older than the Toodoggone crystal ash tuffs, although no stratigraphic evidence for this relationship was seen within the study area. The stratigraphic section exposed east of the fault and south of Jock Creek is fairly clear, but to the north the rocks appear to be different with only one unit that may be correlative (Figure 2-5-5). Further work is required to define the stratigraphy and relationships in this area.

TOODOGGONE VOLCANICS EAST OF SAUNDERS FAULT

18. Monomictic Volcanic Breccia

The lowest unit within this part of the stratigraphy is a dark green fragmental rock consisting solely of subcrowded hornblende-feldspar porphyry clasts. Commonly the clasts are indistinct and the rock resembles a porphyry. Over 100 metres of section is exposed on the west side of Ferricrete Creek (Figure 2-5-3).

19A, B. Heterolithic Green Lapilli Tuff

The breccias are overlain by a green heterolithic lapilli tuff. North of Jock Creek it is predominantly a quartz-biotite-hornblende-feldspar-phyric crystal tuff with indistinct lapilli, while to the south it is more heterolithic with subrounded clasts. Some parts of the section have small chloritic fiammé and higher in the stratigraphy there are distinctive red lithic fragments.

20. Purple Lapilli Tuff

The heterolithic tuff is overlain by 20 to 30 metres of welded purple tuff with weakly to moderately flattened, red, collapsed pumice clasts and a weakly foliated appearance. In the southern part of the map area this unit is overlain by the grey dacite while to the north it is overlain by the units described below.

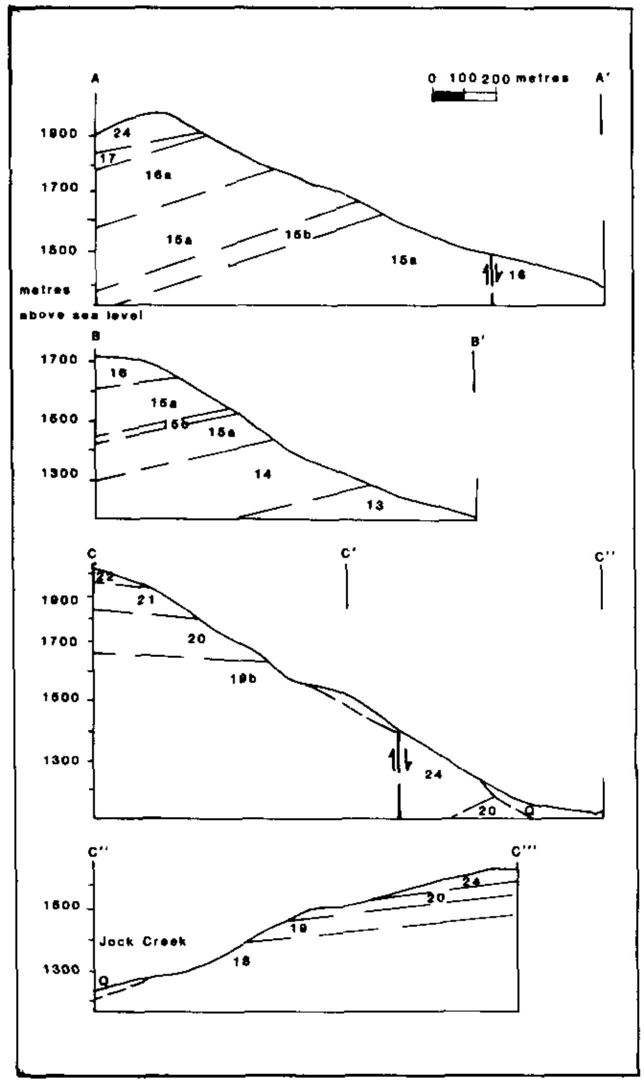

Figure 2-5-5. Sections A-A′, B-B′ C-C″ and C″-C‴ looking east (*see* Figure 2-5-3 for locations).

21. Purple and Green Thin-Bedded Epiclastic Rocks

This 20-metre-thick unit consists of thinly bedded, laminated, graded and crossbedded volcanic siltstone and sandstone with abundant quartz and feldspar crystals.

22. Pyroxene Porphyry Flows and Volcanic Mudstone

Directly overlying the thin-bedded epiclastic rocks is more than 30 metres of medium to coarse-grained pyroxene porphyry flows and pastel-coloured pink and green laminated mudstone.

23. Feldspathic Welded Tuff

A fifth stratigraphic unit is exposed east of the Saunders fault but is always in fault contact with the other units, thus its stratigraphic position is unclear. It is a dark green lapilli tuff with crowded white feldspar crystals, rare to sparse quartz eyes and abundant moderately to highly flattened chloritic clasts. These rocks are exposed in the southeast corner of the map area (Figure 2-5-3) where they are extensively altered.

24. Saunders Grey Dacite

The grey dacite is a distinctive welded lapilli tuff with characteristic uncrowded to subcrowded, green, feldspar porphyry clasts that commonly have a fine-grained equigranular matrix set in a chocolate-brown matrix of ash with abundant quartz, biotite, hornblende and feldspar crystals. The clasts are flattened and aligned. Near the Saunders fault this unit also contains abundant granitic clasts.

The dacite is at least locally unconformable; the porphyry unit that underlies the dacite throughout the rest of the western half of the map area is missing on the east side of Mount Shasta.

INTRUSIVE ROCKS

Intrusive rocks are abundant only within the Saunders fault zone and the feldspathic welded tuff (Unit 23); both host macroscopically similar brown-grey to pink biotite-hornblende-feldspar porphyry dykes, small stocks (Unit A) and fine-grained equigranular granitic rocks (Unit B). Other intrusive rocks in the area are: pyroxene porphyry dykes on the north face of Diamond Peak, a pale-coloured quartz-feldspar porphyry dyke on the south end of Mets Ridge and several dark green aphanitic dykes observed in drill core on the Shasta property.

Takla Group rocks are cut by a pink hornblende-feldspar porphyry and a very shallowly dipping fine-grained equigranular granitic dyke (Units A and B respectively).

STRUCTURE

Most of the stratified rocks within the map area dip gently north or northwest, except for those exposed east of the Saunders fault and north of Jock Creek that dip gently south, and a fault-bounded panel in the centre of the map area that dips moderately northwest.

The stratigraphy is dissected by numerous high-angle faults. In places the net slip can be determined but as the stratigraphy is inclined, most displacements could be any combination of dip-slip and strike-slip motion. The faults mapped clearly group into three orientations; high-angle faults striking 170 to 180 degrees, faults at roughly 150 degrees, and short cross-faults at 050 and 110 degrees. The map area is transected by a major northwest-striking fault, the Saunders fault (Figure 2-5-3), that can be traced south of the Finlay River where it cuts a small stock, indicating up to 5 kilometres of left-lateral displacement (L.J. Diakow, personal communication, 1988). Two important faults striking 170 to 180 degrees cut rocks east of the Saunders fault and have downdropped the Saunders dacite on their east side. A smaller fault, striking 170 degrees, cuts the epiclastics north of the Shasta property and has either an eastern downdropped block or a left-lateral movement. Many other southeasterly striking faults of uncertain movement occur within the map area. The east-southeast-striking faults in the Jock zone (Figure 2-5-6) show right-lateral offset of a stratigraphic contact.

Two property-scale faults bound a block of rotated stratigraphy that hosts much of the Shasta deposit. The western bounding fault is the Shasta fault, which consists of a north-striking, moderately west-dipping segment near Jock Creek and a southeasterly trending segment further south. The dip of the southern segment is uncertain and it may be a different fault, but it is also the western boundary of the rotated block. The eastern margin of the block is the Christmas Creek fault, a prominent topographic linear trending 010 to 030 degrees and locally marked by float blocks of coarse calcite. To the north the rotated block is probably bounded by an east-southeast-striking fault. The rotated block has changed both in strike and dip, implying a plunging hinge line. The southeastern bounding fault is cut by mineralized veins and stockworks that maintain a consistent geometry on both sides of the fault, indicating that rotation occurred prior to the mineralizing event. Near Jock Creek, however, the JM and Creek zones are offset by three or four splays of the Shasta fault, indicating some movement also occurred after the mineralization.

A red, white and black mylonite zone, 2 metres thick, occurs within the laharic deposits of Unit 12. Although impressive, this bedding-parallel zone of deformation is restricted in extent and does not clearly offset the stratigraphy. It is localized within a zone of strong quartz-sericite alteration.

ALTERATION AND MINERALIZATION

Six distinct alteration types were noted during mapping:

(1) Regional propylitic alteration. All rock types except the Saunders grey dacite have been weakly to moderately altered. Chlorite, epidote and carbonate replace the groundmass, mafic phenocrysts and locally feldspar phenocrysts. Alteration intensifies near mineralized zones, for instance, around the Shasta deposit, where mafics are totally replaced by secondary minerals and feldspar phenocrysts are pink.

(2) Some units within the Takla Group are altered to a chlorite-carbonate assemblage with a pale green colour and indistinct primary textures. This alteration type affects most units to some degree, but is locally very strong within the monomictic volcanic breccias of Unit 1d

(3) There are numerous gossanous exposures of quartz(?)-sericite-chlorite-pyrite alteration zones throughout the map area. Alteration intensity varies greatly and can result in total replacement of primary textures by a white, fine-grained mass of quartz, sericite and disseminated pyrite. Rocks may retain some phenocryst outlines and a pale green colour, suggesting the presence of some chlorite, or have a distinct green colour and well-preserved phenocrysts. Some zones, such as the North Black gossan (Figure 2-5-3) are large and exhibit strong alteration, while many others are narrow and probably localized around zones of fracture-enhanced permeability. A large system exposed in the southeast part of the map area contains numerous small, white carbonate-clay-sulphate(?) stringers that locally carry some chalcopyrite and sphalerite.

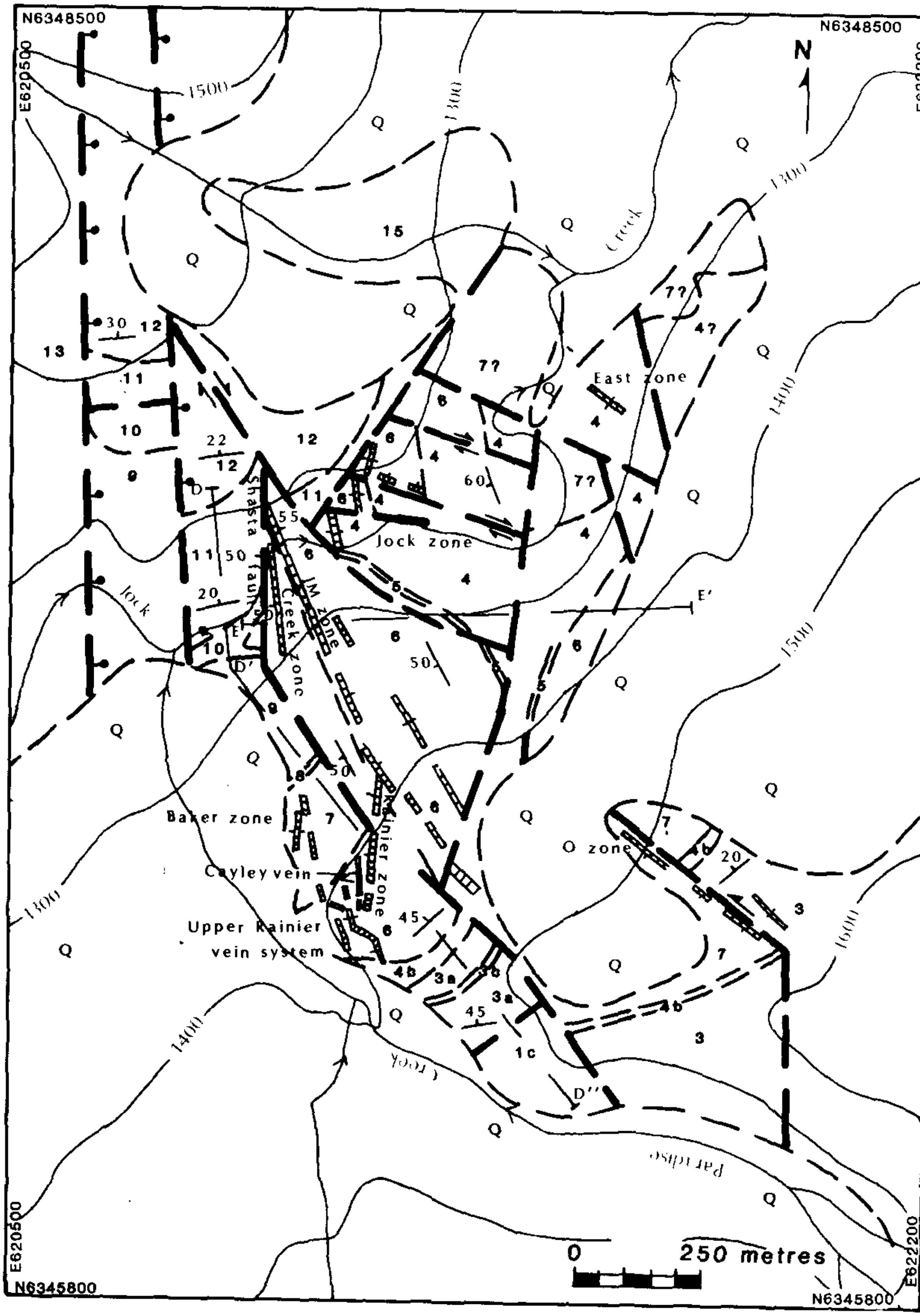

Figure 2-5-6. Shasta property geology.

(4) Several of the strong quartz-sericite-pyrite alteration zones host narrow cores of total silicification, locally with minor clay. These zones weather a characteristic red colour.

(5) Several Type 3 alteration zones in the southeast part of the map area host linear zones of advanced argillic (acid-sulphate) alteration characterized by resistant ribs of intense silicification with disseminated pyrite, minor barite and stringers of foliated (platy) pink alunite within recessive-weathering, rusty, white to grey quartz-sericite-alunite-clay-pyrite alteration. Some of the silicified cores contain sections of a translucent, grey, aphanitic quartz-clay assemblage instead of alunite. Several of the zones trend northeasterly. None of these mineral assemblages has yet been confirmed by X-ray diffraction and are based solely on field observations.

(6) The precious metal bearing stockwork zones at the Shasta property are hosted within zones of potassic alteration and are discussed in detail below.

Alteration is mostly confined to four localities, suggesting four major hydrothermal cells:

(a) Potassic alteration is unique to the area around the Shasta deposit and although all rocks are propylitically altered, fluid flow was largely restricted to relatively narrow, linear fracture zones and their immediate wallrock. These zones host both precious and base metals.

(b) Advanced argillic alteration on the JK property, in the southwest part of the map area, is centred within a very large area of pervasive alteration that is strongest around 060, 110 and 150-degree-striking zones. Where a structural control is obvious, the advanced argillic alteration zones trend northeasterly. No significant precious or base metal values have yet been reported from these interesting zones.

(c) Zones of strong quartz-sericite-pyrite alteration with local cores of intense silicification, minor clay and disseminated pyrite are localized around the north end of the Saunders fault, in the headwaters of Canyon Creek. Sampling by various companies has indicated, at best, anomalous precious metal values from mineralized shears within a small intrusive exposed in Canyon Creek (Figure 2-5-3) and from silicified zones near a pass to the north.

(d) The North Black gossan is a fourth important hydrothermal circulation cell, an elliptical zone of strong alteration. No significant precious metal values have been obtained from this area, even from layered quartz-vein float from the north part of the gossan.

Significant mineralization is not restricted to the alteration zones mentioned above. Coarse galena, sphalerite and chalcopyrite mineralization occurs in coarse carbonate float associated with a fault crossing Rip Ridge north of Jock Creek. Numerous quartz and quartz-carbonate veins with local quartz-sericite-pyrite alteration halos and some pyrite, galena and disseminated grey sulphides occur in the Takla Group at the head of Paradise Creek. Some have yielded significant gold values.

ALTERATION AND MINERALIZATION OF THE SHASTA DEPOSIT

On the Shasta property, mineralization is confined to Units 3 to 7 and the overlying epiclastics are not affected even by the strong propylitic alteration that is pervasive in the felsic porphyry and the lapilli tuff (Figures 2-5-6 and 2-5-7). This suggests they may be pre-mineral but this is not possible since they are involved in post-mineral rotational faulting. Mineralization is best developed in the tuffs and volcanic conglomerate of Units 6 and 7, and to a lesser extent in the underlying porphyry, but appears to feather in the underlying stratigraphy.

Gold and silver are present as the native alloy electrum, as native silver and in argentite with variable amounts of pyrite, sphalerite, galena, argentite and chalcopyrite (Todoruk, 1983) within braided stockwork zones consisting predominantly of quartz, calcite and potassic feldspar with lesser amounts of chlorite, barite, fluorite and sulphides.

Significant precious metal grades are usually associated with visible "grey sulphides" and native metals in quartz and calcite veinlets, but the highest grades yet obtained are from coarse calcite carrying abundant sphalerite, argentite, galena and native silver. The carbonate typically forms the centre of layered quartz-carbonate veins, indicating it was precipitated late in the mineralizing event. The calcite-sulphide-rich zones tend to occur as irregular pods within the stockwork system.

Wallrock alteration around the stockwork systems is characterized by the progressive addition of potassium and silica with a concordant decrease in sodium and aluminum, a reflection of the progressive replacement of the matrix, the clasts, and finally the phenocrysts, by potassium feldspar, minor sericite and quartz with significant amounts of epidote and chlorite remaining up to the margins of the veins. The alteration is marked by a progressive pink coloration of the rock and alteration zones have been defined on the basis of "pinking", first of the matrix, then of included clasts and phenocrysts with only relict textures preserved, and finally total pinking and destruction of all primary textures (Holbek and Thiersch, 1988). The degree and extent of alteration is not related to the grade of the mineralization; electrum has been observed in very narrow stringers cutting weakly altered rocks. Where large pods of carbonate veining are seen, the wallrock is altered to a green chlorite-carbonate assemblage that is locally superimposed on potassic alteration. This is particularly notable in restricted parts of the O and Baker zones.

The stockwork zones consist of numerous anastomosing chalcedonic to coarsely crystalline, locally vuggy quartz and quartz-calcite veinlets. They are referred to as zones because they are highly irregular and rarely form distinct, continuous veins. In places the centre of the system is marked by a grey to pale green fine-grained quartz breccia within broad zones of strong stockworking. These breccias are not particularly rich in precious metals except where crosscut by carbonate and sulphide-bearing veinlets and pods. The central parts of the stockwork zones anastomose and braid, forming an irregular lensoidal pattern within a broader zone of alteration, weak stockwork veining and anomalous gold and silver values. It is difficult to correlate good drill-hole intersections

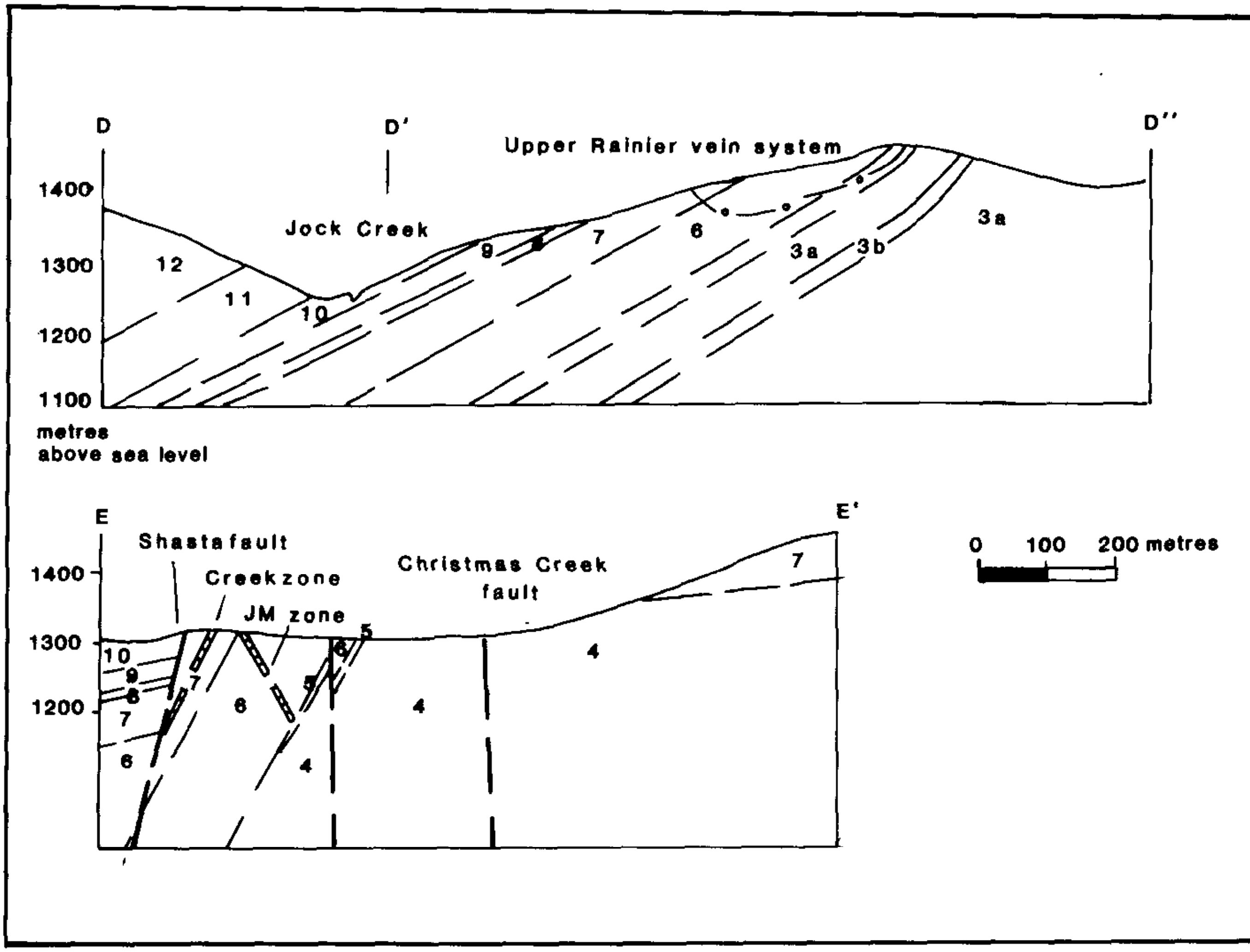

Figure 2-5-7. Section D-D′ and E-E′, looking east and north respectively (*see* Figure 2-5-6 for locations).

only 50 metres apart, yet when viewed on a broader scale, individual zones such as the JM zone can be traced along strike for 800 metres.

Eleven mineralized zones have currently been identified on the property. In the north part of the deposit they form braided stockwork zones while further south in the Rainier and, to a lesser extent, in the Baker and O zones they form narrower and better-defined vein systems. The orientations of the veins and zones are confined to three structural orientations, similar in strike to the trends of the faults (Figures 2-5-6 and 2-5-7). Within the central deposit area the JM zone strikes 150 degrees and dips moderately northeast. The Creek and Rainier zones splay off the JM zone and strike roughly north and dip moderately to the west. These zones carry precious metals and tend to pinch out several hundred metres south of the JM zone. The intersections of the JM zone and these splays commonly yield exceptionally good mineralized intercepts. The third important orientation group are east-southeast-striking veins. Splays off a northern offset of the JM zone, known as the Jock zone, strike 110 degrees and the Upper Rainier vein system can be traced through several segments alternately striking 110 and 150 degrees that in places carry very good precious metal grades but tend to be of limited extent. The Baker zone consists of 150 and 180-degree-striking zones and the East zone consists of mineralization within a southeasterly trending VLF and resistivity anomaly. The JM East zone is an untested zone subparallel to the JM zone.

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