A record of Early Pleistocene glaciation on the Mount Edziza Plateau, northwestern British Columbia

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Abstract: Mount Edziza is a Plio-Pleistocene volcanic complex that is located in the Stikine Terrane in northwestern British Columbia. A sequence of diamictites preserved between Ice Peak Formation basalts on the northwestern flank of Mount Edziza records an Early Pleistocene regional glaciation. The lowest Ice Peak Formation basalt flow (IP1; about 1 Ma) was probably extruded onto glacial ice because it is deformed and brecciated, it is pillowied at the base, it lies directly on hyaloclastite deposits, and there is a lack of fluvial and lacustrine sediments at the base. Fabric measurements from the underlying diamictites are consistent with lodgement processes and indicate northwest and southwest transport directions. These data, and an abundance of striated exotic cobbles, indicate that the sediment was deposited by Coast Mountain ice. Radiometric, paleomagnetic, and stratigraphic data all support the interpretation that diamictites at the section are the sedimentary record of an Early Pleistocene (about 1.1 Ma, isotope stage 32–34) regional glaciation. The normal paleomagnetic polarity of one of the Ice Peak Formation basalts (IP2) records extrusion during the Jaramillo normal polarity subchron (1.07–0.99 Ma) and further constrains the age of the underlying diamictites.

Résumé: Le mont Edziza fait partie d’un complexe volcanique d’âge Plio-Pléistocène qui est localisé dans le terrane de Stikine, dans le nord-ouest de la Colombie-Britannique. Une sequence de diamictites, intercalées entre les coulées de basalte de la Formation d’Ice Peak sur le flanc nord-ouest du mont Edziza, témoigne d’une englacement régionale au Pléistocène précoce. La coulée de basalte qui apparaît à la base de la Formation d’Ice Peak (IP1; datée d’environ 1 Ma) a probablement fait éruption sur la glace de glacier en raison des observations suivantes : elle est déformée et bréchifiée, sa partie inférieure est une lave à coussins, elle repose directement sur des dépôts d’hyaloclastite, et on ne trouve pas à la base de sédiments fluviaux et lacustres. Les paramètres de la fabrique des diamicites sous-jacentes sont compatibles avec des processus typique des tills de base, et ils indiquent que les directions de transport étaient nord-ouest et sud-ouest. Ces données, et l’abondance des gros cailloux exotiques striés, révèlent que le sédiment a été déposé par un glacier de la chaîne Côtière. Les résultats des études radiométrique, paléomagnétique et stratigraphique plaident en faveur de l’interprétation décrivant les diamictites exposées dans cette coupe comme représentant les archives sédimentaires d’avancé(s) glaciaire(s) ayant affecté toute la région, durant le Pléistocène précoce (il y a environ, 1,1 Ma, stage isotopique 32–34). La polarité paléomagnétique normale d’une des coulées de basalte de la Formation d’Ice Peak (IP2) enregistre l’éruption survenue durant le sous-chrone de le Jaramillo (1,07–0.99 Ma) de polarité normale, ce qui autorise une estimation plus précise de l’âge des diamicites sous-jacentes.

[Traduit par la rédaction]

Introduction

In this paper, the stratigraphy and paleomagnetism of a Plio-Pleistocene sediment section on Mount Edziza are investigated. Mount Edziza is located in the Stikine Terrane in northwestern British Columbia (Fig. 1) and forms part of the north-south-trending Stikine Volcanic Belt. Many researchers have noted that intercalated sediments and basalts are common in the Stikine Plateau region (Dawson 1898; Johnson 1926; Watson and Mathews 1944; Read and Psutka 1985). Souther and Symons (1974) identified diamictites deposited on the western flank of Mount Edziza as being, in part, of glacial origin. Souther (1992) invoked the presence of glacial ice on Mount Edziza to explain the morphology of specific volcanic flows and their mode of emplacement. Regional stratigraphic associations and detailed dating of the basalt flows led to the suggestion that some of the sediment may be Plio-Pleistocene in age (Souther et al. 1984).

The purpose of this paper is to describe these sediments in detail and to interpret them in terms of their glacial history; in particular, an attempt is made to constrain the ages of the sediments. In light of the paucity of terrestrial records...
of early Quaternary Cordilleran glaciations, it was felt that these sections warranted further study. Recent research in the genetic differentiation of diamictons and detailed investigations of tills and lahars (Mills 1984, 1991) increased the probability that these diamicites could be reliably interpreted. The Sezill Creek section was chosen for detailed investigation because it offers good lateral and vertical exposure of both sediments and basalt flows and is easily accessed. This latter point is critical for practicality and economy of effort, as the surrounding terrain is extremely rugged.

Regional geological setting

Mount Edziza forms the northern part of the Mount Edziza Volcanic Complex and is bounded to the west by the Coast Mountains and to the east by the subdued peaks of the Skeena Mountains and the Klastline Plateau. The volcano is made up of overlapping basaltic shields that are overlain by composite domes of largely intermediate composition (Souther et al. 1984). Isolated outcrops of intrusive rock exist on the western flank of Mount Edziza, to the north and west of the Sezill Creek section described later in the text (Souther 1992).

The section described in this paper is located on the northwestern side of the Big Raven Plateau (Fig. 1) along the northern side of the Sezill Creek valley (el. 1350 m) and consists of diamicite, stratified and massive sediment, and intercalated basalt flows. The sediments and intercalated basalts lie above the felsic Armadillo Formation that has been K–Ar dated at 10.2 ± 1.4 to 6.1 ± 0.1 Ma (Souther 1992). The intercalated basalt flows belong to the Ice Peak (IP) Formation, which has not been reliably dated due to high atmospheric argon content (Souther 1992).

Stratigraphy

In this paper all formation designations are from Souther (1992). We informally designate distinct Ice Peak Formation basalt flows as members within the formation to facilitate detailed section description. Sediment located between Ice Peak basalt flows (both volcanoclastic and otherwise) was considered by Souther (1992) to be part of the Ice Peak Formation. We refer to these sediments as informal members within the Ice Peak Formation, as this paper demonstrates that the sediments and the basalts are closely related. The informal subdivisions in this paper apply only to the Sezill Creek locality. They are required to facilitate description and discussion and establish the intimate relationships between volcanic and sedimentary deposits in the area.

Mount Edziza area

The basic stratigraphic and age relationships for the Mount Edziza Volcanic Complex (not including the Spectrum Range) from the time of deposition of the Armadillo Formation (7.1–6.1 Ma) to the deposition of the Edziza Formation (0.9 ± 0.3 Ma) are shown in Fig. 3. Ages for all volcanogenic formations are from Souther (1992). Two sedimentary units that contain diamicite interpreted as till are depicted in the general stratigraphic column (Fig. 3) as being bounded by the Nido (about 4.4 Ma) and Ice Peak (about 1.0 Ma) formations and separated by the Pyramid Formation (about 1.1 Ma). However, each of these basal formations exhibited a unique distribution, hence the stratigraphy within the illustrated time frame may vary at any given location on the Mount Edziza Plateau. The distributions of Ice Peak and Pyramid formation basalts do not overlap.

Diamictite preserved below Pyramid and below the lowermost Ice Peak basalts on Mount Edziza is generally thick (>20 m) and poorly sorted and contains two or more distinct units separated by erosional boundaries. A preliminary examination of poorly exposed diamicrite at Cache Hill and Camp Hill (Fig. 1) indicated that they contained exotic intrusive megaclasts, complex stratigraphy, a paucity of pyroclastic debris, and, possibly, multiple diamicite beds. Souther (1992) noted that at the Tennaya Glacier section (Fig. 1), Pyramid Formation lacustrine tuff interfingers with a thick diamictite that is overlain by Ice Peak basalt; apparently diamicite deposition and Pyramid Formation emplacement were coeval.

The distribution of the Pyramid and Nido basalts does not extend to the Sezill Creek section (Souther 1992), and hence the time between deposition of the basalts that overlie and underlie the thick diamicite is greatest within this section (about 5.6 Ma).
Fig. 2. Sezill Creek section. Ice Peak Formation basalts (Ice Peak 1, Ice Peak 2) were deposited about 1.0 Ma and the lower Armadillo Formation basalt was deposited approximately 6.0 Ma (Souther 1992). The majority of the sediments are diamictites (DA, DB1–DB3, DC, DD). The wedge-shaped unit (CBPL sandstone) is a volcanogenic sedimentary deposit. The sediment section DB3–DC is about 30 m thick.

Sezill Creek section
The Sezill Creek section consists of two thin diamictite members (DD and DA) preserved between Ice Peak Formation basalts, and a 30 m thick stratified sediment and diamictite succession (DB1–DB3, CBPL sandstone, DC) deposited between the lowest Ice Peak and Armadillo Formation basalts (Figs. 2, 4).

Armadillo Formation Basalt (AFB)
The AFB forms the base of the Sezill Creek section (Fig. 2). AFB consists of a single felsic lava flow that has been dated at about 7.1–6.1 Ma (Souther 1992). The top of the flow is neither polished nor striated.

Diamictite member C (DC)
Diamictite C is 4–8 m thick and coarse-grained with a high percentage of gravel-sized clasts. This sediment lies stratigraphically below the CBPL volcanogenic member. The plane of contact is subhorizontal (Fig. 5). Though DC is poorly exposed, the exotic megaclasts noted are highly weathered and friable; weathering rinds on these clasts are well developed. DC is more strongly lithified than the underlying diamictites.

Cross-bedded and parallel-laminated (CBPL) sandstone member
This member has a strongly concave-up, erosional upper contact with DB1 and a roughly horizontal (though undulatory) lower contact with underlying DC (Fig. 5). The CBPL sand-
Fig. 4. Stratigraphy, age, and paleomagnetic correlations for the Sezill Creek section. The age of Ice Peak Formation basalts is interpreted as being about 1.0 Ma. Ice Peak 2 and DA are correlated with the Jaramillo subchron within the Matuyama reversed epoch. DB1–DB3 are correlated with the Matuyama; the CBPL sandstone falls within a reversal below the Jaramillo subchron. Paleomagnetic scale after Cande and Kent (1995) and Shackleton et al. (1990); oxygen-isotope scale after Ruddiman et al. (1989).

OXYGEN ISOTOPE AND PALEOMAGNETIC TIME SCALES

δ18O

5.0 (cold) 4.0 3.0 (warm)

BRUNHES 0.78

MATUYAMA

0.99

JARAMILLO

1.070

1.19 COBB MT.

SEZILL CREEK SECTION

ICE PEAK 4

ICE PEAK 3

ICE PEAK 2

ICE PEAK 1

DB1

DB2

DB3

CBPL SAND

ARMADILLO FM. (LES 09)

about 6.0 Ma

about 1.0 Ma

< 4.0 Ma NIDO FM. AGE

> 1.0 Ma ICE PEAK AGE

Pillow Basalt

Parallel-Laminated Sand

Boulder Lag

Normal Polarity

Reversed Polarity

Ice Peak Basalt

Cross-Bedded Sand

Diamicton (Medium)

Diamicton (Coarse)

Armadillo Basalt

Rhythmic Beds

Ice Advance

Regional Ice Advance

N

samples were taken from within the parallel-laminated beds.

Diamictite member B1 (DB1)

This member is about 10 m thick (Figs. 2, 5) and contains some megaclasts that have maximum long-axis dimensions of about 0.5 m. Much of the sediment is fine grained (Fig. 6A). Individual parallel-laminated beds in DB1 are up to 70 cm thick, can be traced laterally for over 40 m, and consist of alternating 1 cm thick sandy and silty laminae (Fig. 6B). The laminae are often normally faulted. Deforma-
Fig. 5. Cross-bedded, parallel-laminated volcanogenic sandstone (CBPL sandstone). The contact with overlying DB1 is strongly concave, erosional, and is marked by a lag of cobbles and boulders that is one clast thick. This unit is composed primarily of felsic and mafic volcanogenic sediment. The sediment is strongly cemented, which may indicate that it is considerably older than the overlying, more friable diamictites. Person for scale at arrow.

Fig. 6. (A) Subhorizontal erosional contact (at arrow) between diamictites DB2 and DB1. Interspersed in the rhythmic sediment (DB1) are lenses of poorly sorted, clast-supported gravel (box, Fig. 6B). (B) Lenses shown in (A) and interpreted as proglacial, lacustrine debris-flow deposits originating either from floating ice or a nearby ice front. The book in the photographs is 16 cm high.

tion is common and consists of injection structures in intercalated gravel. At select locales the faulting crosscuts the deformation structures. The sandy laminae contain isolated, well-rounded pebbles, and more rarely, cobbles and boulders that are often striated. The laminated beds occur rhythmically throughout this member and are occasionally separated by 0.1-0.2 m thick lenses of coarse sand and pebble-rich diamictite in which both matrix and clast support is evident (Fig. 6B). These beds have an undulatory (presumably erosional) lower contact and a planar upper contact. Sandy silt laminae (1 cm thick) drapes are common but rarely extend laterally more than 1 m. Clasts of intrusive rock, usually phyllite or diorite, are common within the pebble beds (approx. 5%). The contact with overlying DB2 is sharp and erosional and is marked by an increase in the coarse sediment concentration and termination of the thick rhythmically deposited silts (Fig. 6A). The base of DB1 is concave upwards and exhibits a prominent one-megaclast-thick layer of rounded to subangular cobbles and boulders.

Diamictite member B2 (DB2)
Diamictite B2 is about 2.5 m thick, and contains about 75% matrix. Megaclasts within the sediment have long axes up to 0.4 m long and are generally well rounded (Figs. 7A, 7B). The diamictite is light brown and exhibits faint, isolated, 1-4 cm thick, horizontal, laminated lenses (Fig. 7B). A few (approx. 1%) cobbles of intrusive and metamorphic rock were noted, and most exhibited well-developed weathering rinds. The matrix sediment is dominantly silty with a fine sand component. The contact with DB3 is undulating and is accompanied by a marked increase in megaclast concentration. The lower contact is sharp, well defined, and contains a concentration of larger clasts that appear to be embedded in the finer grained sediment of DB1.

Diamictite member B3 (DB3)
This diamictite is 4-7 m thick (Figs. 2, 5) and matrix sup-ported (60% matrix, 40% clasts), with a maximum clast diameter of 1.0 m. Megaclasts are subrounded and occasionally facetted and striated and are dominantly of igneous extrusive origin; however, megaclasts of intrusive (diorite, approx. 5%) and metamorphic rock are also present. The fine-grained silty matrix is grey to tan. Lenses of parallel-laminated sand are common and tend to drape some of the cobbles. Isolated pods of openwork pea gravel are also present. Large clasts are often preferentially arranged as undulating semihorizontal layers within this diamictite, particularly at the lower boundary with DB2, where megaclasts appear to be embedded. The upper contact of DB3 grades into a thin layer of medium to coarse, sorted volcanogenic sediment, which in turn grades into a layer of palagonite that coarsens upwards into a volcanogenic breccia.

Ice Peak member 1 (IP1)
IP1 is a thin, uniform basalt flow that has a pillowed base and contains yellow to buff-coloured palagonite deposits, indicating that the basalt flow was deposited in a cold, perhaps subaqueous environment. The top of IP1 is polished and appears striated; however, detailed measurement of striation orientation was not possible due to the lithified nature of the contact with overlying DA.
Diamictite member A (DA)
Diamictite A is found between IP1 basalt and IP2 basalt (Figs. 2, 4). This member averages about 2.5 m in thickness and contains about 50% megaclasts (pebble to cobble sized), some of which are angular and others subrounded to well rounded. A few exotic, striated igneous cobbles were noted. The matrix is composed of fine sand and silt, and occasional discontinuous laminae and convolutions were noted. The upper contact of the diamictite grades into well-sorted medium to coarse pyroclastic sediment (scoriae and lapilli) overlain by palagonite.

Ice Peak member 2 (IP2)
IP2 is similar to IP1 and also is pillowed and contains palagonite deposits at its base. However, in contrast to IP1 the top of IP2 does not appear to be striated.

Discontinuous diamictite member (DD)
A discontinuous diamictite lies between IP2 and IP3 basalt flows (Fig. 4). The diamictite contains both rounded and angular cobbles, which account for about 40% of the sediment volume. The matrix is medium grained, the main constituent being fine sand and silt; no internal structures were evident. The megaclasts are almost solely of extrusive origin; megaclasts of intrusive rock accounted for less than 1% of the clast volume. Palagonite deposits and isolated pods of graded medium-grained pyroclastic material (scoriae, ash, and lapilli) form the upper contact with the overlying basalt.

Ice Peak 3 and 4 (IP3, IP4)
IP3 is a discontinuous basalt flow that has a pillowed base which is also highly fractured and contains abundant palagonite; it was probably deposited in an aqueous environment. The top of this basalt flow does not appear to be striated. IP4 has neither a pillowed base nor a polished top surface; it does not appear to have been deposited in contact with water or ice. Poorly exposed, discontinuous volcanogenic sediment lies between these two flows.

Exotic clast lithology and provenance
The bulk of the megaclasts in the diamictite members are of extrusive origin and presumably have a local source; however, DC, DB1-DB3, and DA contain a significant number of exotic (intrusive) clasts. Well-rounded and angular diorite pebble- to boulder-sized clasts are most common (approx. 5%) and likely originated from Jurassic and Triassic plutons that circumscribe the Edziza Plateau. Phyllite pebbles and cobbles were also noted (approx. <2%) and were most commonly found as isolated, striated, and faceted angular clasts in DB1. These clasts likely originated from the Palaeozoic-aged rocks in the Boundary Ranges of the Coast Mountains located to the west of the Sezill Creek site (Fig. 1).

Fabric data
At the Sezill Creek section, fabric measurements were taken on rod-shaped cobble-sized clasts in DB2 and DB3. Both diamictites exhibit a preferred orientation of rod-shaped clasts and a well-developed cluster tendency (Fig. 8). Two fabric directions were noted. N07°E for the upper diamictite DB3, and S78°E for the middle diamictite DB2 (Fig. 8). The dip of the long axis in both members is relatively shallow, however, the mean directions are offset by about 90°. These strong fabrics suggest that the megaclasts in both sample groups are preferentially aligned; the cluster tendency is an indication of the strength of the directional force. Limited exposure and (or) a paucity of rod-shaped megaclasts precluded fabric measurements in DD, DB1, DA, and DC.

Interpretation of stratigraphy and sedimentology
It is essential to determine the genesis and provenance of the diamictites. Three possibilities exist: (i) local volcanogenic origin, (ii) local (Mount Edziza) glacial origin, or (iii) regional glacial origin.

Till described by Souther and Symons (1974) was classified as such due to the presence of well-rounded, exotic clasts. They surmised that these clasts could only have been transported to the Edziza Plateau by regional glacial pro-
**Fig. 8.** Fabric orientations for diamictites DB3 and DB2 (lower hemisphere projections) indicate that the direction of transport for these diamictites was most likely from the south and west. Arrows indicate a-axis orientation. Paleocurrent directions in the underlying CBPL sandstone are from the northeast. Both diamictites exhibit strong fabrics in which the cluster tendency is greater than the girdle tendency.

Diamictite DB3

\[
\text{N = 25} \\
S1 = 0.66 \\
\text{Peak Position: 194.9°/14.8°}
\]

Diamictite DB2

\[
\text{N = 50} \\
S1 = 0.787 \\
\text{Peak Position: 291.8°/11.2°}
\]

cesses. However, in the absence of additional indicators of glaciogenic transport, there exists the possibility that the exotic megaclasts were incorporated during reworking of previously deposited sediment. As well, diamictites can be produced in both glaciogenic and volcanogenic environments, though in the latter they are primarily the result of debris-flow processes (Scott 1986).

The distinction between regionally and locally derived tills must also be established. A large ice cap exists on Mount Edziza at present (Fig. 1). Though the moraines left behind by Holocene advances extend only 2 km from the present ice margin, it is possible that a larger ice cap may have existed in the past on Mount Edziza. The glacial sediments preserved between basals then may be a record of Mount Edziza centred rather than regional ice advance.

DC is sporadically exposed and does not contain features diagnostic of either volcanogenic or glaciogenic deposition, although the presence of exotic megaclasts may indicate that glaciation, at the very least, preceded its deposition. The CBPL sandstone is composed primarily of fluvially derived volcanogenic sediment. The sediment may have been deposited as outwash in a meltwater stream similar to those that now bisect the eastern portion of the Big Raven Plateau. Both the CBPL sandstone and underlying DC are well cemented, indicating that they both may predate deposition of DB1 by a considerable amount of time.

DB1 contains sedimentological characteristics more consistent with subaqueous deposition. The fine-grained beds are rhythmic and contain isolated phyllitic and dioritic pebbles and cobbles, interpreted as dropstones, that are striated, angular, and deform underlying sediment. The poorly sorted coarser sand and gravel beds are deposited directly on the laminated sediments, which, at that contact, exhibit deformation, indicating that the coarser sediment was probably “dumped,” with little potential for sorting, on the rhythmic sediments.

DB3 and DB2 exhibit strong, unimodal fabrics, suggesting that the sediment was deposited by lodgement or englacial processes (Fig. 8). The fabrics compare favourably with other basal ice debris fabrics described by Mills (1991) and fall well outside the envelope for debris-flow deposits. Many studies have summarized the general characteristics of fabrics formed in subglacial environments (Levson and Rutter 1988; Mark 1973; Mills 1977, 1991; Shaw 1985), and these sediments are generally characterized by strong fabrics in which the a axes of rod-shaped stones in basal tills are oriented near parallel to ice flow and lie in planes that vary from subhorizontal to dipping up-glacier. The fabric data also suggest transport directions (from the north and the west) that are incongruous with volcanically initiated debris flows that, if they occurred, must have originated to the east of the Sezill Creek locality.

The pillowed basalts and abundant palagonite at the contact of IPl and underlying DB3 may be further evidence of the presence of ice at the section. Both of these volcanic features are indicative of basalt deposition in saturated conditions. As there is no indication that fluvial or lacustrine conditions existed immediately prior to deposition of IPl, the presence of ice is inferred.

The diamictite succession (DB1-DB3) is interpreted as being indicative of deposition in an ice-proximal, subaqueous (DB1), and subglacial environment (DB3 and DB2). The truncation of the underlying CBPL sandstone and the deposition of a boulder lag may reflect fluvial erosion at the onset of regional glaciation. An increase in the availability of meltwater and blockage of drainage routes during advance may
have resulted in the formation of an advance-phase proglacial lake and the deposition of rhythmically bedded silts and clays (DB1 sediment). The presence of phyllitic clasts is an indication that Coast Mountain Ice had inundated the Edziza Plateau at this time. Diamictites DB2 and DB3 indicate regional glacial ice cover conditions. The normal faults that crosscut both the poorly sorted coarse sediment and rhythmic sediment in DB1 may be indicative of postdepositional deformation by overriding ice. Different transport directions suggested by the fabrics in DB2 and DB3 may reflect an adjustment in regional ice flow direction as glaciation progressed.

Striated exotic clasts and the lack of stratification and sorting suggest that DA may have been deposited by glaciogenic processes. The polished surface of the underlying basalt flow (Ice Peak 1) indicates that glaciation may have occurred after extrusion of the basalt. The base of the overlying basalt (Ice Peak 2) is pillowed and contains palagonite, indicating aqueous deposition, perhaps by extrusion onto ice or into meltwater. Combined, these features indicate that glacial ice cover may have occurred after deposition of Ice Peak 1 and prior to extrusion of Ice Peak 2.

DD does not contain sedimentological features that conclusively indicate deposition by either glaciogenic or volcanic processes. However, exotic clasts within the member indicate that at some time prior to or synchronous with the deposition of the diamictite, regional glacial processes must have been active at the section.

### Paleomagnetism

#### Paleomagnetic data

The Sezill Creek section contains five basalt flows, all of which were sampled. The only fine-grained, undisturbed sediments suitable for paleomagnetic sampling were found in the CBPL sandstone; all diamictites were far too coarse for paleomagnetic work. The interpreted stratigraphy and paleomagnetics of the Sezill Creek locality are shown in Fig. 4; paleomagnetic data for each sampling site are summarized in Table 1.

All samples were collected using a gas-powered diamond drill, and cores were oriented by solar and (or) topographic bearings. Remanence measurements were made on a Schonstedt SSM-1 spinner magnetometer, which was controlled by an IBM personal computer. Stepwise alternating-field (AF) demagnetization was carried out using a Schonstedt GSC-5 unit and stepwise thermal demagnetization was completed using a Schonstedt TDS-1 furnace.

Normal-polarity magnetization was observed in IP2 basalts (LES03; Fig. 9) and Armadillo Formation basalts (LES09). The decay upon AF demagnetization is smooth and a substantial part remains after treatment at 100 mT. Intensities fall by almost an order of magnitude during demagnetization. Orthogonal plots (Fig. 9) illustrate that small magnetizations imposed by the present field were present and were removed at low fields, at which there was linear decay to the origin. There is no evidence to suggest that the normal magnetizations at these sites record anything other than the ambient field at the time of basalt deposition.

The principle magnetization was reversed for IP4 (site LES01), IP3 (site LES02), and the IP1 (site LES04) basalts (Fig. 9). Orthogonal plots are sometimes “hooked” (a directional migration), and the first part of the plot may be showing the removal of magnetizations directed along the present field, but the remainder of the plot shows linear decay to the origin. The reversed magnetizations at these sites also very probably record the reversed ambient field at the time of deposition.

For IP3 basalt (site LES02), the initial magnetization is normal, which, upon treatment, gives way to a reversed polarity magnetization (Fig. 9). Decay occurs rapidly during demagnetization, which corresponds to a normally magnetized overprint of low coercivity. At high fields, the magnetization tends to be scattered, but is clearly of reversed polarity.

Paleomagnetic samples at the CBPL sandstone site (LES05 – LES08) do not exhibit smooth decay upon thermal demagnetization. Orthogonal plots exhibit a pronounced hooked form and begin to decay in a linear fashion after the third treatment level (200°C). No sense of direction can be derived for sites exhibiting this type of magnetization (Fig. 10), however there is no evidence that the reversed magnetization is anything other than a record of the ambient field at the time of sediment deposition.

### Paleomagnetic conclusions

IP2 basalt has normal polarity. The age of the Ice Peak Formation cannot be radiometrically determined, due to argon contamination (Souther 1992); however, the age of the underlying Pyramid Formation is about 1.1 Ma and the age of the overlying Edziza Formation is about 0.9 Ma. Hence the Ice Peak Formation is about 1 million years old. It is
therefore likely that IP2 basalt correlates with either the Jaramillo normal polarity subchron (1.070-0.990 Ma; Cande and Kent 1995) or the Cobb Mountain subchron (1.19 Ma; Shackleton et al. 1990). Correlation with the Jaramillo event is more probable, as the radiometric age of the lower bounding Pyramid Formation is 1.1 Ma. IP basalts 1, 3, and 4 have reversed polarity, indicating that they were deposited during the Matuyama Epoch. We infer that IP3 and IP4 basalts were deposited after the Jaramillo event and are therefore younger than 0.990 Ma (the upper age limit for the Jaramillo event, Cande and Kent 1995). We infer that IP1 basalt was deposited before the Jaramillo event and therefore was probably deposited between 1.10 and 1.070 Ma.

The reversed polarity of the volcanogenic sediment (CBPL sandstone) does not aid in the resolution of the age of the overlying strata, as at least 13 reversals occur in the period following the deposition of the underlying Armadillo Formation (7.1-6.1 Ma) and prior to the deposition of the Ice Peak Formation (about 1.0 Ma) (Cox 1982). However, the low $k$ values and nonlinear decay to origin may be the consequence of complex overprinting indicative of a prolonged period of deposition for both the CBPL sandstone and the underlying DC.

**Discussion**

We attribute diamictites DB2 and DB3 to deposition during Coast Mountain ice advance rather than by Mount Edziza centred ice on the basis of fabric orientation and exotic megaclast lithology. Interpretations of late Fraser (Late Wisconsinan) ice flow in the region provide an effective analogue. In the Stikine River valley east of Telegraph Creek (Fig. 1), Glacial Lake Stikine developed when advancing Coast Mountain ice blocked westward drainage of the Stikine River (Ryder and Maynard 1991; Spooner 1994). East-flowing ice eventually inundated the Edziza Plateau depositing exotic Coast Mountain erratics in the surficial till (Spooner 1994).

The ages of DB2 and DB3 are difficult to constrain, because neither the underlying CBPL sandstone (reverse polarity) nor the lower bounding Armadillo Formation (about 6 Ma) provide closely limiting ages. However, the following stratigraphic indicators suggest that these diamictites date from the same time as the IP1 basalt. In addition to the palagonite described earlier, pillow structures and brecciation characterize the base of PI; it is most likely that IP1 was extruded onto ice, the same ice that deposited the diamictites immediately underneath the basalt. These con-
Fig. 10. Paleomagnetic site ChRM mean directions and polarities. At sites LES03, LES04, and LES09, site means approximate the paleopole position. Site LES01 shows a significant displacement to the east which may reflect the influence of the nondipole field. Sites LES02 and LES05–LES08 show high scatter and, though directions are not determinable, specimens polarities are clearly reversed.

Siderations would place the age of DB2 and DB3 between 1.1 and 1.070 (Fig. 2).

There is evidence from elsewhere on the Edziza Plateau that is complementary to this conclusion. Similar sediment successions to that at Sezill Creek were observed at a reconnaissance level at Camp Hill and Cache Hill, and Souther (1992) described similar successions at the Tennaya Glacier section (Fig. 1). Multiple diamictites, striated megaclasts of intrusive origin, and a lack of volcanogenic debris within these sections indicate that they too are probably the sedimentary record of glacial conditions. Souther (1992) noted that at the Tennaya Glacier section, the Pyramid Formation lacustrine tuff interfingers with the diamictite; he further believed that much of the Pyramid Formation he observed in outcrop was probably deposited during a period of ice cover. These relationships suggest the diamictites there are coeval with the Pyramid Formation, with an age of 1.1 Ma. We suspect, but cannot demonstrate, that the diamictite sequences from Sezill Creek and Tennaya Glacier, and possibly the other sections as well, are records of a single, or closely related, glaciation.

DA was most likely deposited by glacial processes as well. As we were unable to collect fabric data for DA, we were unable to establish whether the glaciation responsible
was either regional or local. However, Souther (1992) considered that Ice Peak basalts were deposited close in time, and IP1 basalt (which underlies DA) has a polished top surface and a pillowed and fractured base, indicating extrusion below ice. It is possible, therefore, that both DA and DB2–DB3 were deposited during the same glacial event.

Conclusions

Fabric data, regional stratigraphy, and sediment and basalt morphology at the Sezill Creek section indicate that ice advance in the Coast Mountains inundated the Big Raven Plateau between 1.1 and 1.070 (isotope stage 32–34; Fig. 4). Other diamicites may record separate glacial events, the ages of which are difficult to constrain.

The Sezill Creek section also provides an Early to Middle Pleistocene paleomagnetic record. The paleomagnetic stratigraphy has helped constrain the age of the Ice Peak Formation basalts, which, due to contamination, do not provide reliable ages.

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This paper is dedicated to the late Ronald Janzen, owner—operator of Tel-Air Flight Services, Telegraph Creek, B.C. Ron provided accommodation and logistical support for many researchers in northern British Columbia during the last decade. He was killed while flying in September 1994. He will be missed by many.

References


