Regional Jurassic and Cretaceous facies assemblages, and structural geology in Bowser Lake map area (104A), B.C.

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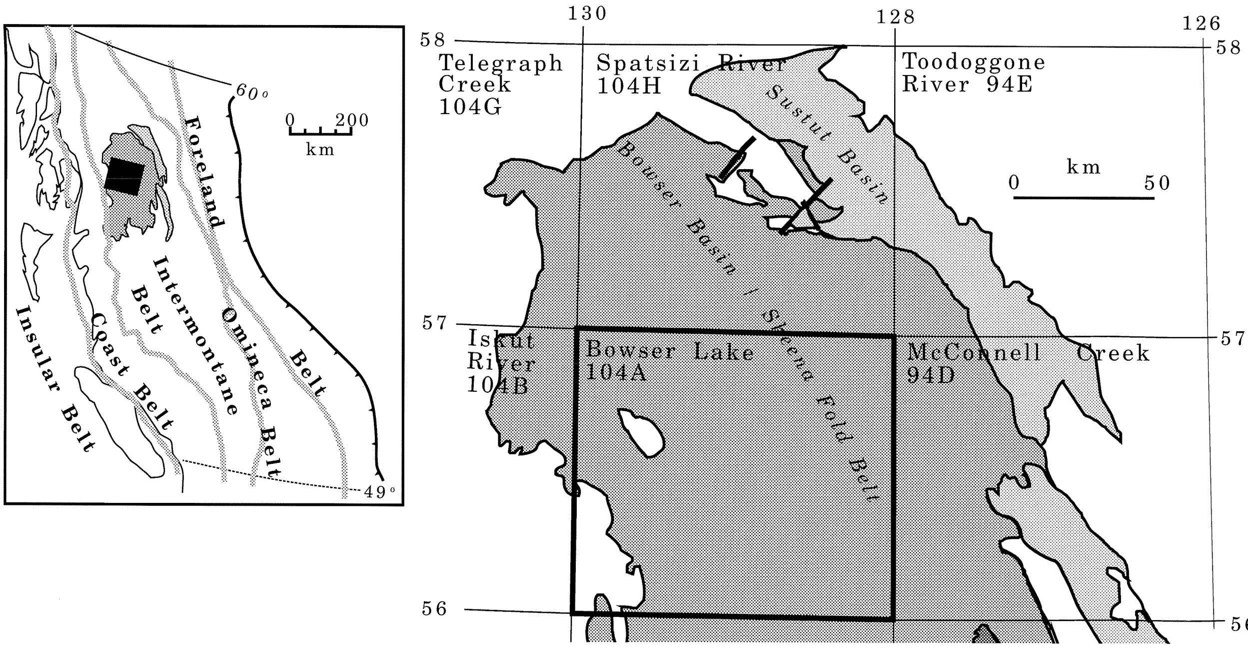


Figure 1. Location of the Bowser Basin in the Canadian Cordillera, Bowser Lake map area, and NTS map areas referred to in text.

ABSTRACT

Bowser Lake map area (104A) is underlain primarily by the Middle Jurassic to mid-Cretaceous Bowser Lake Group. Other bedrock units are Lower to Middle Jurassic Hazelton Group, two small plutons, and at least 3 small outliers of Pliocene Maitland volcanics. The Bowser Lake Group is divided into 3 broad lithofacies assemblages, comprising depositional environments ranging from deep marine, to open platformal marine, to nonmarine. Devils Claw Formation is the only formal lithostratigraphic unit of the group mapped.

All pre-Tertiary stratified rocks are intensely folded and faulted, and are included in the Skeena Fold Belt. Northeast vergent folds dominate, but southwest vergent ones are also present. As in other parts of the fold belt, fold geometry, orientation and scale vary widely, but unique to this region are local large scale recumbent folds.

RESUME

Le sous-sol de la région cartographique de Bowser Lake (104A) contient principalement les roches du Groupe de Bowser Lake qui couvrent l'intervalle du Jurassique moyen au Crétacé moyen. Les autres unités du substratum sont les roches du Groupe jurassique de Hazelton qui s'échelonnent du Jurassique inférieur au Jurassique moyen, deux petits plutons, et au moins trois petites buttes témoins composées de roches volcaniques pliocènes de Maitland. Le Groupe de Bowser Lake se laisse subdiviser en trois grands assemblages de lithofaciès englobant divers milieux sédimentaires, du type marin profond passant à un milieu marin ouvert de plate-forme, puis à un milieu non marin. La Formation de Devils Claw est la seule unité lithostratigraphique formelle du groupe qui ait été cartographiée.

Toutes les roches stratifiées prétertiaires sont intensément plissées et faillées, et font partie de la zone de plissement de Skeena. Les plis de vergence nord-est sont prédominants, mais il existe aussi des plis de vergence sud-ouest. Comme dans d'autres parties de la zone de plissement, la géométrie, l'orientation et l'échelle des plis varient largement, mais des plis couchés de grande envergure caractérisent par endroits cette région.

INTRODUCTION

A regional study of the northern Bowser Basin began in 1985 with the goal of elucidating its depositional, structural and thermal histories. With a framework of facies and structural styles for the northern basin established (Evenchick, 1987, 1988, 1989, 1991a,b, 1992; Ricketts and Evenchick, 1991; Evenchick and Green, 1990), the month of August, 1992, was devoted to regional mapping of Bowser Lake map area (NTS 104A; Fig. 1). The primary goals were to augment the more detailed facies and structural studies to the north, to complete sampling for a regional thermal maturation study, and to produce an updated 1:250 000 map for an area in which no current map is available.

This report outlines the map units in 104A, with emphasis on the stratigraphy and structure of the Bowser Lake Group. More than 80% of Bowser Lake map area is underlain by Middle Jurassic to Cretaceous clastic rock (GSC, 1957). Other bedrock units in the area include Lower and Middle Jurassic volcanic and clastic rock of the Hazelton Group, small erosional remnants of Pliocene volcanic rock, and two small plutons. All Cretaceous and older strata in Bowser Lake area are part of the Skeena Fold Belt, a regional fold and thrust belt which accommodated at least 160 km of northeast shortening between latest Jurassic or Early Cretaceous time and latest Cretaceous or early Tertiary time (Evenchick, 1991b). After the Bowser Basin was first recognized in 1956 (GSC, 1957), studies in Bowser Lake area focused on either Lower to Middle Jurassic Hazelton Group and underlying strata (Monger, 1977; Grove, 1986; Greig, 1991, 1992), or on the southern Groundhog Coalfield, in the northeast-most corner of the map area (Richards and Gilchrist, 1979; Bustin and Moffat, 1983; Cookenboo and Bustin, 1989; MacLeod and Hills, 1990). A short period of petroleum exploration by Dome resulted in one unsuccessful exploration well drilled near Oweegee dome (Koch, 1973). Other exploration in the area has focused on base and precious metal prospects in the Hazelton Group, and coal in the Groundhog Coalfield.

HAZELTON GROUP

Lower to Middle Jurassic Hazelton Group strata occur in two regions on Figure 2. One is a structural culmination of the Skeena Fold Belt southeast of Bell II, called Oweegee dome. Triassic and older strata there are overlain by varied thicknesses of volcanic and volcaniclastic rock of the lower Hazelton Group, and all are overlain by clastic rock of the upper Hazelton Group (Greig, 1991, 1992). Hazelton Group also underlies much of the southwest corner of the map area, where undivided Hazelton Group is overlain on the east by clastic rock of the upper Hazelton Group (Salmon River Formation). In both areas, upper Hazelton Group is gradationally overlain by Bowser Lake Group. Because the focus of this study is the Bowser Basin, we have only mapped Hazelton Group strata immediately underlying the Bowser Lake Group. We follow the use of Salmon River Formation outlined by Anderson and Thorkelson (1990) for these strata.

Salmon River Formation

Anderson and Thorkelson (1990) divided the Salmon River Formation of Iskut map area into a lower, generally thin, but lithologically distinctive member, and an upper member composed of three facies defining north-trending belts. The lower member overlies felsic volcanics of the Mount Dilworth formation (Anderson and Thorkelson, 1990), and is characterized by fossiliferous, rusty weathering, calcareous greywacke of Toarcian age. The upper member is dominantly volcanic in the west (Snippaker Mountain facies), volcanic and clastic in a central belt (Eskay Creek facies), and siliceous, thinly interbedded tuff and shale ("pyjama beds") in the east (Troy Ridge facies).

The lower member occurs locally in southwest Bowser Lake area in what is assumed to be a continuous belt, and commonly in the Oweegee area (Greig, 1992). It varies from 0.5 to 5 m thick in the Oweegee area, up to 150 m thick northwest of Bowser Lake (about lat. 56°35), and at least 5 m thick southwest of Bowser Lake (56°20). It is characterized by rusty weathering, brown, poorly sorted calcareous and fossiliferous greywacke, debris flow conglomerate, and rusty weathering black shale. Some fossil collections in the Oweegee Range are Toarcian in age. Fossils northwest of Bowser Lake (lat. 56°35), are of Early Aalenian and late Toarcian-Early Aalenian age (H.W. Tipper and T.P. Poulton, written comm., 1992). Southwest of Bowser Lake (lat. 56°20) they are Late Toarcian to Aalenian in age (H.W. Tipper, pers. comm., 1992).

The upper member of the formation northwest of Bowser Lake includes thinly-bedded pyritic shale and silty mudstone, welded dacitic lapilli tuff, massive pillow basalt and pillow breccia, and debris flow conglomerates with abundant felsic clasts, all complexly interrelated with common lateral changes in thickness. These strata are overlain conformably by approximately 10 m of siliceous cherty tuff, similar to the "pyjama beds". Strata are similar to the Eskay Creek facies of Anderson and Thorkelson (1990).

Surprise Creek facies

The upper member of the Salmon River Formation is significantly dissimilar to the named facies of Anderson and Thorkelson (1990) in the several sections observed between Bowser Lake and the southern map boundary, and we propose the name Surprise Creek facies for the unit in this region. The thickness of the sections varies from 1300 m southwest of Bowser Lake (complete section), to at least 2000 m east of Yvonne Peak (incomplete section) and about 1000 m east of Entrance Peak (probably close to complete). There is much lithologic variation, as noted in the descriptions below starting from the northwest and going south.

Southwest of Bowser Lake the lower member is overlain by thick intervals of white weathering fine and medium grained sandstone intercalated with rusty weathering siltstone and fine grained sandstone. Siliceous, laminated, rusty weathering, fine grained sandstone and siltstone bearing some resemblance to "pyjama beds" occur sporadically over about 100 m in the lower half and near the top. These strata are in gradational contact with dark siltstone and fine grained sandstone of overlying Bowser Lake Group.

Southeast of Mount Pattullo the Dilworth formation is overlain by about 500 m of debris flow, reworked lapilli tuff, and tuff breccia, and then by 500 m mudstone with

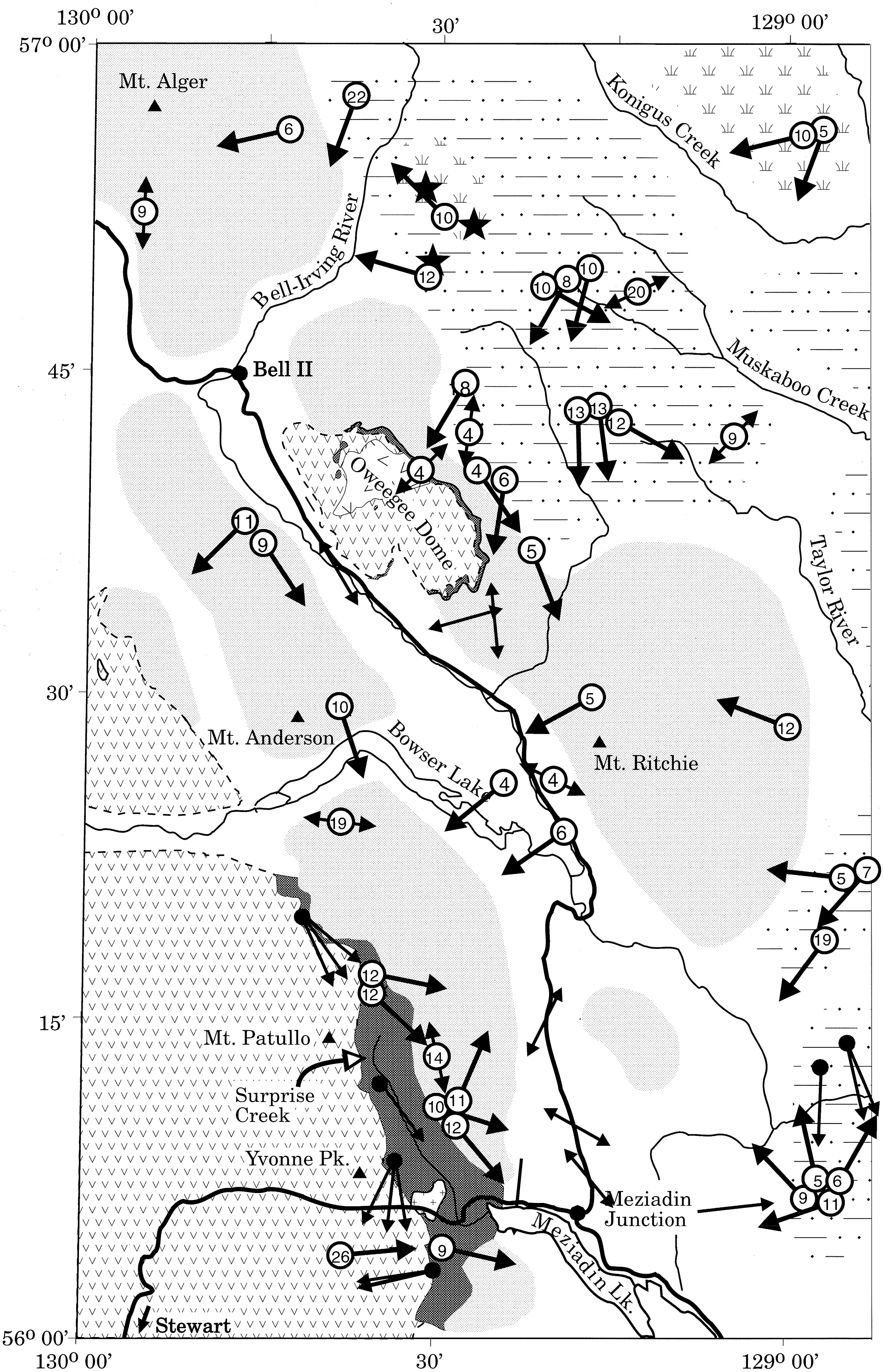
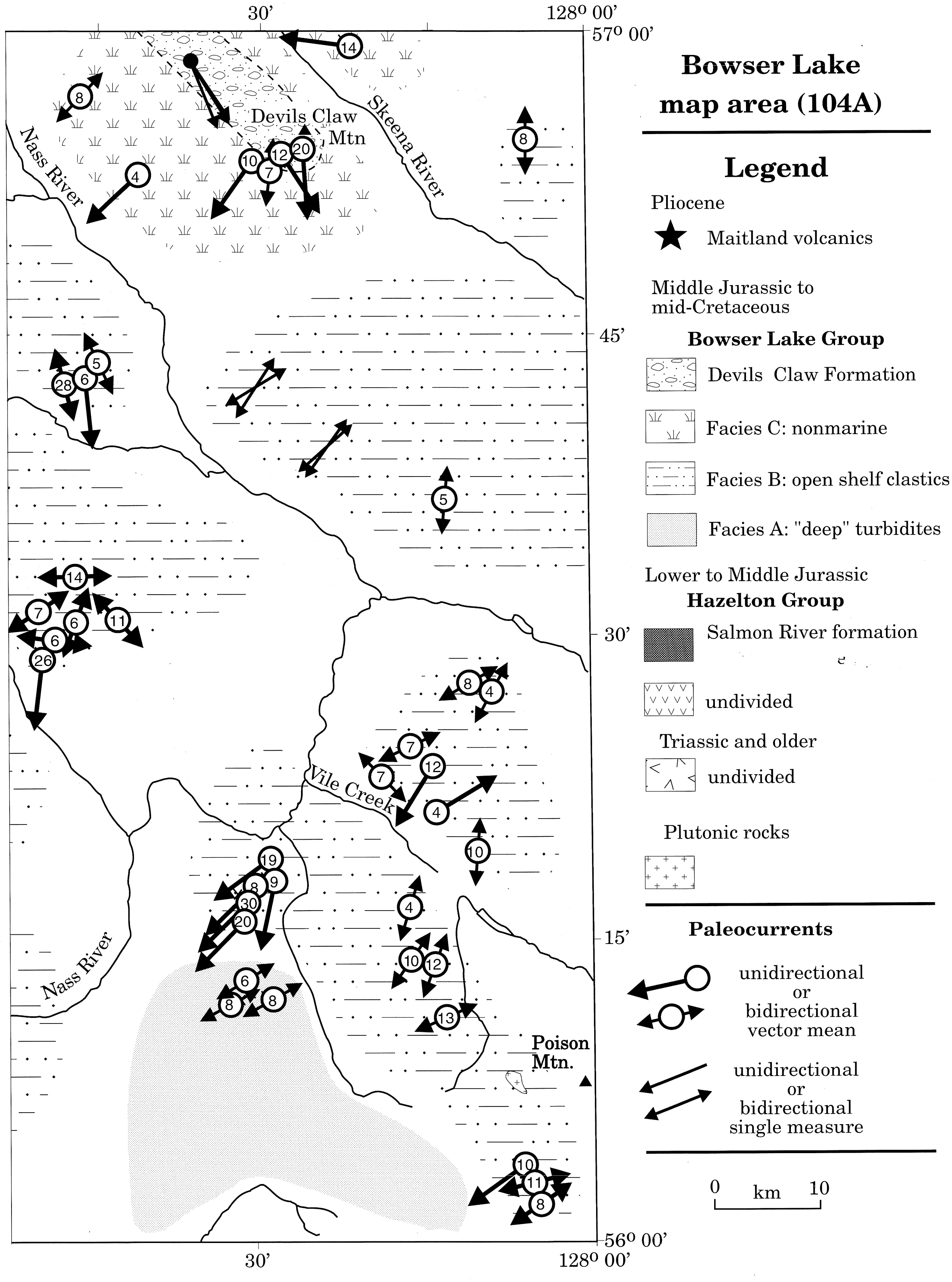


Figure 2. Geology of Bowser Lake map area. Paleocurrents are shown as vector mean arrows from sites where statistically significant trends were measured (number of measurements shown in circle placed over or near site of



measurements). All paleocurrents are corrected for bed tilt and in rare cases, fold plunge (where plunge >10°). Circular standard deviation from mean is generally <10°, rarely up to 30°.

siliceous and tuffaceous siltstone near the top. The primary thickness of these strata is unknown owing to pervasive flattening fabric; the stratigraphically highest rocks are an unknown thickness below the basal Bowser Lake Group.

East of Yvonne Peak, at least 50 m of foliated grey and green weathering massive coarse volcanic clastics, probably debris flows, are overlain by well bedded fine grained volcanic clastics, which grade up into grey volcanic clastics including conglomerate, dark weathering siltstone, and fine grained sandstone. Upsection, these strata grade into well bedded, light green and white weathering siltstone, fine grained sandstone and minor medium grained sandstone, exhibiting abundant flame structures, ball and pillow structure, climbing ripples, crossbedding, parallel lamination, and contorted bedding. Thin bedded siltstone and fine grained sandstone intervals alternate with thick bedded massive medium grained sandstone. White weathering medium grained sandstone increases in proportion and maximum thickness up section to at least 80% medium to coarse grained sandstone in beds to 3 m thick at the topmost beds. These strata are an unknown thickness below the basal Bowser Lake Group.

Southwest of the west end of Meziadin Lake (east of Entrance Peak), white and rusty weathering, massive volcanic debris flow, possibly the lower member of Salmon River Formation, is overlain by about 50 m of grey and rusty weathering siltstone, and fine to medium grained sandstone, including massive sandstone beds and poorly sorted conglomerate. These strata grade up into about 130 m of very rusty weathering, laminated to thin bedded siliceous siltstone and fine to coarse grained sandstone, in places rippled. Some of the siliceous siltstones bear moderate resemblance to the "pyjama beds" which comprise most of the Troy Ridge facies. These rocks are gradually overlain by less siliceous, darker weathering, thicker bedded medium to coarse grained feldspathic wacke, some with angular volcanic rock fragments in a muddy matrix, and up to 70% massive and laminated black siltstone and mudstone. These rocks are conformable with, and grade into the overlying Bowser Lake Group.

The upper Salmon River Formation in southwest Bowser Lake map area is dominantly clastic, but highly variable in detail, and contains few of the "pyjama beds" characteristic of the Troy Ridge facies to the west. These strata are strongly dissimilar to the informally defined facies of the Salmon River Formation. For this reason we propose a fourth facies, representing a new eastern belt which is considerably less siliceous and contains more medium and coarse grained clastics than the Troy Ridge facies to the west. Paleocurrent measurements in the Surprise Creek facies indicate paleoflow was east and southeast (Fig. 2). This is the first direct evidence for a westerly source for clastic rocks of the Salmon River Formation, and it is consistent with Anderson and Thorkelson's (1990) suggestion that clastics of the Salmon River Formation were deposited in a back-arc setting of a west-facing arc (volcanic Salmon River Formation). Farther south, Greig (1991) suggested a local source for strata transitional between Salmon River Formation and Bowser Lake Group.

Salmon River Formation is gradational over several tens to hundreds of metres into the overlying Bowser Lake Group. The Salmon River Formation can be distinguished from the Bowser Lake Group on the basis of: darker and rustier weathering of the Salmon River Formation; generally, more sandstone in the Bowser Lake Group; Salmon River Formation may include more siliceous strata. Lithologies restricted to the Salmon River Formation are "pyjama beds", and poorly sorted, immature sandstone with angular volcanic fragments in the upper part. The Salmon River Formation generally contains less mature feldspathic arenite or wacke, whereas sandstone in the Bowser Lake Group is typically more mature arenite with a large proportion of chert clasts.

BOWSER LAKE GROUP

In a revision of Mesozoic stratigraphy for north-central British Columbia, Tipper and Richards (1976) named the Bowser Lake Group for widespread Middle to Upper Jurassic clastic rocks in the Smithers and Hazelton map areas (southern Bowser Basin). They divided the group into the Ashman Formation and overlying undivided Bowser Lake Group. The former term for mainly marine shale, sandstone and minor conglomerate of Late Bajocian to Early Oxfordian age, and the latter term for shallow marine to nonmarine facies of Late Oxfordian to Kimmeridgian age.

In the northern Bowser Basin the term Ashman Formation has been applied to a dominantly shaly and silty unit with lenses of chert pebble conglomerate (Gabrielse and Tipper, 1984; Evenchick, 1987; Evenchick and Green, 1990; Green, 1991). Other strata in Spatsizi, Toodoggone, and Telegraph Creek map areas (Fig. 1) have been grouped into lithological units of uncertain stratigraphic relationship, pending the results of an ongoing biostratigraphic compilation. A paleoenvironmental reconstruction has been proposed for a part of the northwest basin at Tsatia Mountain and Cartmel Lake (Ricketts and Evenchick, 1991). Strata comprising the Groundhog Coalfield in southeast Spatsizi and northeast Bowser Lake map areas are formally named (Cookenboo and Bustin, 1989), although the boundaries and ages of the units are contentious (see McLeod and Hills, 1990, 1991; Cookenboo et al., 1991), and the units have not been applied in regional mapping (e.g., Evenchick and Green, 1990; Evenchick, 1992). In general, the Currier Formation consists of nonmarine to marginal marine shale, siltstone, sandstone, coal and carbonate. It is the main coal bearing unit in the Groundhog-Klappan coalfield, and is either latest Jurassic (Cookenboo and Bustin, 1989) or Early Cretaceous (MacLeod and Hills, 1990) in age. The McEvoy Formation is composed of nonmarine shale, siltstone, coal, sandstone and conglomerate, and is of Early Cretaceous age (Cookenboo and Bustin, 1989; MacLeod and Hills, 1990). The Devils Claw Formation consists of nonmarine conglomerate, sandstone, siltstone, and shale and is either Early Cretaceous (MacLeod and Hills, 1990) or middle Albian to Cenomanian or younger in age (Cookenboo and Bustin, 1989). The subtle differences between the Currier and McEvoy formations, and the need for relative stratigraphic position to define them, render the proposed lithostratigraphic units indistinguishable on a regional scale. This is in part because the structure beyond the Beirnes syncline (the only place these units have been mapped) is considerably more complex, and thick unfolded sections are rare. The Devils Claw Formation is a lithologically distinctive conglomeratic unit, although Jurassic strata including as much conglomerate are present in Spatsizi map area, and are clearly not related to the Devils Claw Formation. Considering the prospect of an unwieldy nomenclature based on environment of deposition where the structure is complex and vertical and lateral repetitions of facies are present (e.g., Evenchick, 1992), we have avoided formal stratigraphic nomenclature with the exception of the Devils Claw Formation, and delineated facies with no stratigraphic implications at this preliminary stage of analysis of the basin.

Lithofacies of the Bowser Lake Group

Figure 2 shows the Bowser Lake Group subdivided into 3 lithofacies assemblages considered to represent different environments of deposition (although transitional facies changes are common in many areas). The stratigraphic relationships between the facies are generally unknown owing to intense contractional deformation, the lack of biostratigraphic control, and the regional nature of our study. Identification of the 114 fossil collections made during this reconnaissance mapping program should provide at least regional control on the age relationships of these facies. The Devils Claw Formation as defined by Cookenboo and Bustin (1989) is also present in the northeast map area.

Facies A: sandstone-siltstone-mudstone turbidites

A broad lithofacies belt stretching from the northwest to the southeast corners of the map area is dominated by intercalated siltstone to silty mudstone with interbedded very fine to fine grained sandstone. These strata are commonly black weathering, dark grey or brown fresh colour, and massive or parallel laminated. In many places this facies also includes 20-95% light grey, resistant weathering fine to medium grained chert arenite, typically in laterally continuous thin to thick beds (most 5-25 cm thick but beds 25 cm to >2 m thick are present). Medium grained sandstone is abundant northwest, southwest, and southeast of Oweegee dome. Internally the resistant sandstones tend to be massive or planar laminated, with rare crosslaminated asymmetric ripples at the top, capped or abruptly grading into overlying silty mudstone interbeds (Bouma sequence types T_{BE}, T_{AE}, T_{ABE} and T_{ABCE}). Load structures and tool marks occur at the base of some beds. Where the resistant sandstone beds are common, either thickening/coarsening or thinning/fining upward trends can often be discerned, generally on 10-50 m scales. These sequences are in places vertically stacked, rarely displaying slight angular depositional discordance between sequences, which suggest broad channelized lower contacts to some sequences. These stacked sequences are generally hundreds of metres thick in total, and the entire facies is in most places probably more than a kilometre thick. A typical section occurs east of Mt. Ritchie where at least 1000 m of section comprises about 50% stacked thinning and thickening upward interbedded sandstone-siltstone-silty mudstone sequences and about 50% siltstone-silty mudstone in 10-20 m thick intervals lacking resistant sandstone (Fig. 3). These strata are overlain by >500 m of section which is about 70% siltstone to silty mudstone and 30% sandstone. In some places (e.g., Mt. Anderson) soft sediment deformation features are common, including laterally extensive synsedimentary folded layers metres to tens of metres thick and minor extensional faults. In these areas medium grained sandstone is generally a minor component. Paleocurrents measured from ripple cross lamina and tool marks indicate paleoflow was roughly towards the southwest (Fig. 2); a direction compatible with the vergence directions of synsedimentary slump folds.

These strata probably represent deposition in a continental marine deep shelf, slope to rise setting. There are no sedimentary structures indicative of sub-wave base deposition and no *in situ* macrofossils were found. The fine grain size and abundance of thick, laterally persistent synsedimentary slump structures is typical of marine slope to rise environments. The vertically stacked sandstone sequences are interpreted as overlapping submarine fan sand-rich lobes sourced from regions exposed broadly to the northeast as supported by regional paleocurrent trends. Areas with less well developed sandstone sequences are probably deposits in lobe fringe to inter-channel fan areas.

This facies occurs mainly in west Bowser Lake area, in gradational contact with the underlying Salmon River Formation. The chert-rich sandstone compositions, paleoslope and paleocurrent indicators all indicate deposition from the northeast for this facies, consistent with data from the northeast side of the basin (Eisbacher, 1974). This suggests that the apparent "west side" of the basin is a post-depositional, structural feature, and that there is no preserved western margin coeval with Facies A.

Facies B: open shelf clastics

Strata indicative of deposition in open platformal marine environments, probably generally above storm wave base, underlie most of the northeast half of the map area. The strata are thinly interbedded sandstone, siltstone and silty mudstone; with little or no conglomerate. A shallow marine environment is suggested by an association of sedimentary structures, overall composition and character, and particularly the presence of such diagnostic features as hummocky and swaley cross-stratification, flaser and lenticular bedding, rare tidal crossbedding, and bivalve coquinas, some *in situ*, but others transported. Paleocurrent indicators are generally southwesterly directed where unidirectional (most from asymmetric ripple crosslamination) which we interpret as reflecting a source area to the northeast. This is consistent with the bidirectional paleocurrent indicators (most from symmetrical ripples) which show a general southwest-northeast orientation. Many indicators are also either southeast or northwest directed, probably parallel to the main shoreline. This lithofacies association encompasses a variety of marine shelf environments, from deep (± stormy) clastic shelf, which may include turbidites shed off a delta front, to very shallow and tidally influenced, but open marine environments. This variety cannot be characterized by one or two typical sections. The following descriptions of specific areas cover much of the range of sections observed. The total thickness is unknown, but at least 500 m, and very likely much more.

South of Poison Mountain. In the southeast map area is a section at least 300 m thick composed of 20% medium grained sandstone and 80% siltstone and fine grained sandstone. The siltstone and fine grained sandstone occurs as either 50 to 100+ m thick intervals of recessive, massive to parallel laminated black siltstone with rare orange claystone beds, or the same black siltstone thinly interbedded with other rocks in 2 to 20 m thick intervals. The 2-20 m intervals are resistant to weathering, and composed of 1-3 m intervals of: black laminated fine grained sandstone; black fine grained sandstone interlaminated with white weathering fine to medium grained sandstone in varying proportions, commonly crossbedded, with starved ripples, symmetrical ripples, flaser and lenticular bedding, rare flame and other loading structures; dominantly white weathering crosslaminated or parallel laminated fine to medium grained sandstone; white weathering massive or parallel laminated medium grained sandstone. The presence of symmetrical ripples suggest that these strata were deposited above storm wave base, and the lenticular and flaser bedding are probably littoral to shallow subtidal deposits. Much of the sandstone appears to be the product of turbidity flows, possibly pro-deltaic or storm-generated density underflows.

Southeast of Nass River and Taylor River junction. Ridges in this area expose at least 500 m of stratigraphic section. The upper part (150 m+) is more than 90% laminated fine grained siltstone. Parallel lamination is most common, with some normal graded bedding, asymmetrical ripples and climbing ripples; rare massive, 2-5 m thick medium grained sandstone beds are also present. These are underlain by similar strata with an increased proportion of medium grained sandstone, mainly massive chert arenite. At least 100 m is composed of 70% medium grained sandstone in beds 0.5 to 2 m thick, separated by 1-2 cm black siltstone. Ripple marks, flame and other load structures are present where bedding is thin. Lowest in this section is dominantly black laminated siltstone and fine grained sandstone with common 0.5 to 2 m medium grained sandstone beds, commonly rippled.

In this general region the facies contains flaser and lenticular bedding with symmetric and asymmetric ripple marks and complexly overlapping trough and planar crossbedded sandstone lenses. Swaley crossbedding is also rarely present. Vertical and horizontal trace fossils are common in some beds, including abundant *scolithus* burrows. Fine plant debris is abundant in some beds.

These strata are considered shallow marine on the basis of abundant current and wave ripples and trace fossils of the *scolithus* ichnofacies assemblage. The turbidite-like sandstones may be storm deposits on a stormy clastic shelf, or prodeltaic deposits shed from the north or northeast, but in a generally more sheltered part of the shelf than other areas of this lithofacies. Rare swaley crossbeds are probably storm deposits and complexly crossbedded sandstone lenses are likely small bar complexes.

Northwest of Nass River and Muskaboo Creek junction. A tightly folded section of uncertain thickness in this area comprises at the west end 80-90% medium grained sandstone. The sandstone occurs in cycles composed of 1-10 m platy medium grained sandstones, some hummocky cross-stratified, overlain by 10-20 cm bivalve coquina and capped by 1-5 cm laminated or massive dark fine grained sandstone. Coquina beds here consist of disarticulated and broken shell material and are in some places normally graded, probably reflecting some degree of transport. In the east, medium grained sandstone comprises 30% of the section, finer grained clastics 70% and coquina is absent. The sandstone is well bedded, platy, commonly rippled, and displays hummocky cross-stratification (Fig. 4). Fine grained sandstone and siltstone is laminated or massive, and bioturbation is common. The presence of symmetrical ripples and hummocky cross-stratification is compatible with an above storm-wave-base environment of deposition on an open marine shelf.

Southwest of Muskaboo Creek and north of Taylor River. Ridges in this area contain exposures of interbedded sandstone and silty mudstone about 300-500 m thick. These occur in overall fining upward "megasequences" at least 300 m thick, but which internally comprise coarsening and thickening upward sequences 10 to 50 m thick (Figs. 5, 6). A typical sequence has a basal component (20-50%) of medium grey siltstone, silty mudstone and very fine grained sandstone, all massive to laminated with slightly wavy lamina and abundant bioturbation. Light grey, fine to medium-grained thin sandstone beds increase in abundance and thickness in the central to upper part of the sequence, all capped by 5 to 10 m of light grey, medium-grained lithic arenite which internally shows a complex mix of planar and trough crossbeds and wavy planar beds. Bivalve coquinas occur in the upper parts of some coarsening/thickening upward sequences. They are orange grey weathering, generally <30 cm thick but rarely up to 1 m, and comprise broken and common articulated shells all in a coarse grained bioclastic matrix of the same material. The articulated shells occur in clusters, infilled by broken shell debris, probably reflecting preservation *in situ*, or only very slight transport.

The complex crossbedded sandstone and bivalve coquinas of the upper parts of these sequences suggest an interpretation of shallow marine bars prograding over relatively lower energy areas of the shelf. The *in situ* bivalve coquinas contrast to the transported coquinas of the previously described area, perhaps reflecting a shallower facies. The overall fining upward megasequence in this area could reflect a general transgression, a response to eustatic changes or, more likely tectonic controls in this active basin.

South of Nass River, east of Meziadin Lake. In this area dark grey siltstone and very fine grained sandstone are predominant in a section at least 750 m thick. The strata are generally laminated to thin bedded with slightly wavy bedding. Much of the siltstone appears bioturbated and fine plant debris is common in places. Flaser bedding and crosslaminated starved ripples are rarely present. Also present are intervals up to 20 m thick of light brown weathering, fine grained sandstone in thin to thick beds. Many of the beds are wavy to vaguely internally rippled. Several well preserved sets of planar crossbedding shows strongly oblique to opposed current directions in adjacent beds. Reactivation surfaces are also apparent in some sets. Both features suggest tidal current deposition. Where traceable laterally the sandstone bedsets occur in lenses with broadly channelized bases. These are interpreted as tidal channels in a generally quiet but very shallow part of the shelf.

Facies C: nonmarine

In some respects, these strata resemble some of the sections described above, but they include minor coal, *in situ* roots, and abundant plant fossils and lack marine fossils. They are present along the northeast margin of the map area, and extend northward into Spatsizi map area. Strata immediately surrounding the Devils Claw Formation include a transition into shallow marine strata.

North of Skeena River. A uniform section at least 1000 m thick in this area consists of about 40% massive, parallel, and planar crossbedded medium grained sandstone and 60% dark fine grained sandstone with laminated and massive siltstone and mudstone, some densely packed with plants. Minor constituents are rusty and buff weathering limy claystone 15-20 cm thick, and grey limestone 20-30 cm thick. Plants are well preserved, and abundant throughout the section. Fining up cycles are common and medium grained sandstone occurs in laterally discontinuous sheets (Fig. 7). The lenticular sandstone bodies, fining up cycles, abundant crossbeds and well preserved plants, and the absence of marine fossils together suggest a fluvial succession.

Northeast of Konigus Creek. The section northeast of Konigus Creek is at least 800 m thick, with channels of conglomerate more common at the base, in an overall fining up sequence. Chert pebble conglomerate in sheets more than 15 m thick make up >80% of the basal 100 m. The conglomeratic section is overlain by a finer grained facies with only 5-10% chert pebble conglomerate in discontinuous, channelized sheets between 3 and 15 m thick. The remaining 90 to 95% of

Figure 3. Thick section of Facies A east of Mt. Ritchie, showing cycles of turbidites.

Figure 4. Hummocky cross-stratification in sandstone of Facies B between Muskaboo Creek and Nass River.

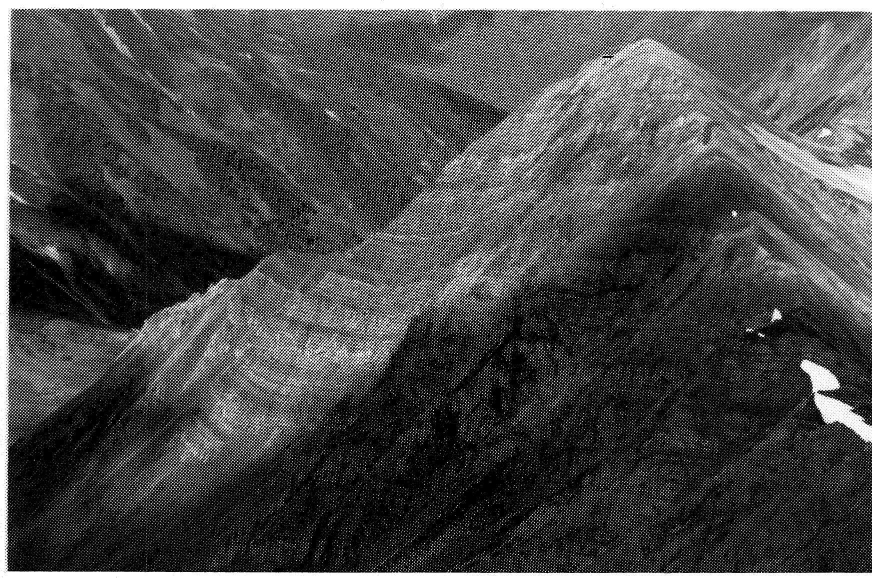


Figure 5. Facies B strata organized in an overall fining upward megasequence which consists of stacked coarsening and thickening upward sequences, each about 10-30 m thick. Total thickness of exposed section is about 300 m.

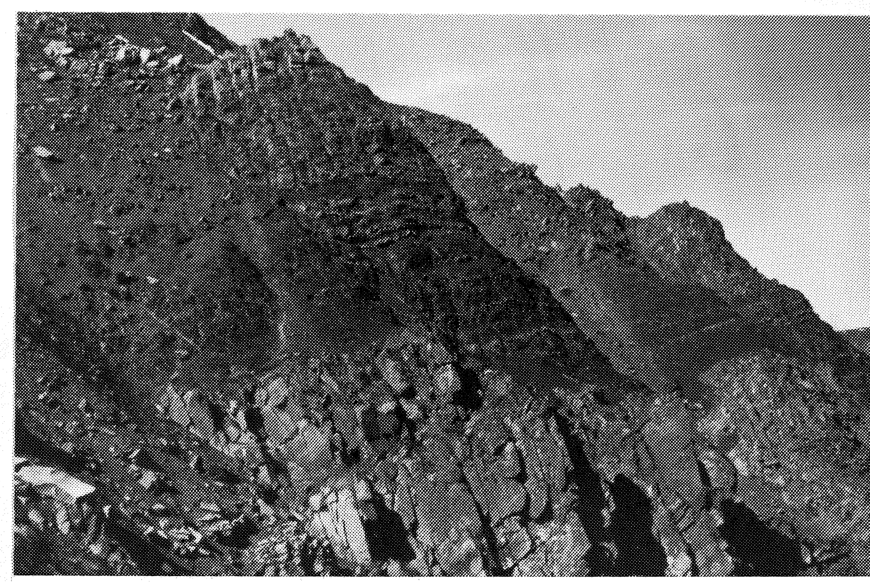


Figure 6. One coarsening and thickening upward sequence of Figure 5, changing from dark grey silty mudstone at the base (in sharp contact with sandstone top of sequence below) to light grey sandstone at the top.

Figure 7. Sandstone lenses in Facies C nonmarine section northeast of Skeena River. Cliff face is about 50 m high.

the section is medium and fine grained sandstone and siltstone. Medium grained sandstone is massive, poorly bedded, or planar crossbedded, wacke and arenite, some with *in situ* roots (Fig. 8).

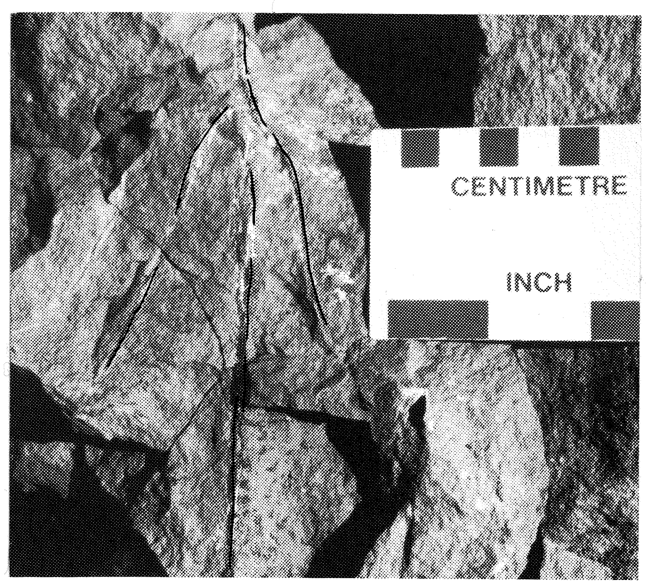


Figure 8. *In situ* roots in nonmarine strata (Facies C) northeast of Konigus Creek.

Beds are generally 0.5 to 3 m thick, and are interbedded with dark, fine grained sandstone, laminated siltstone, and massive carbonaceous siltstone densely packed with plants. Well defined fining up cycles of medium grained sandstone to siltstone or carbonaceous mudstone are 8 to 20 m thick, and in some places include conglomerate at the base. Thick sections of apparently disorganized medium grained sandstone and fine grained sandstone are also present. The assemblage of channelized conglomerate, planar crossbedding, fining up cycles, abundant well preserved plants, *in situ* roots, and an absence of marine fossils suggest a fluvial system.

East of Bell-Irving River and northeast of Bell II. In this area, about 300 m of strata is composed of thinly interlayered medium grained sandstone, massive and thinly bedded fine to medium grained sandstone and laminated siltstone and massive, carbonaceous siltstone/mudstone with abundant well preserved delicate plants. Chert pebble conglomerate comprises less than 10% of the section, and is only 3 to 5 m thick, except at the top of the section where three conglomerate layers, each 15 to 20 m thick are present. Planar crossbeds are present in some medium grained sandstone. Possible *in situ* roots occur in thinly bedded sandstones overlying the conglomerate. Fining upward sequences are not as well-developed here as in the areas described above. A coastal floodplain environment with minor fluvial channels is suggested.

Devils Claw Mountain area. Strata examined below the Devils Claw Formation at Devils Claw Mountain and on ridges immediately west were assigned to the McEvoy Formation by Cookenboo and Bustin (1989). At the type section ridge (the southern extension of Devils Claw Mountain) >700 m of strata is well-exposed. Dark grey siltstone and silty mudstone is dominant, massive to thin bedded, with abundant plant material, rarely including thin coal. Fine to medium grained sandstone thin to thick beds occur as laterally discontinuous lenses hundreds of metres long, many with channelized bases. Both planar and trough crossbeds occur internally in some beds, indicating southerly paleoflow. These sandstones form the bases of 10-30 m thick fining upward cycles. Orange brown weathering clastic limestone and calcareous siltstone are rarely present and <20 cm thick. Well-preserved *in situ* roots occur in limestone and fine grained sandstone beds. In the upper part of the section pebble conglomerates occur in laterally discontinuous composite bedsets up to 5 m thick. The thickest conglomerate has a well defined channelized base and is internally well stratified with 5-30 cm thick beds of moderately well sorted clast-supported pebbles which show poor normal grading, some capped by up to 10 cm of coarse grained sandstone (Fig. 9). Pebbles in some beds are complexly graded and define subtle planar crossbedded sets indicating southerly paleoflow. Most pebbles are chert, with generally <10% volcanic and other compositions.

The association of fining upward sandstone - siltstone cycles, abundant plant debris, rare coals and *in situ* roots, and graded-stratified conglomerates strongly supports a fluvial-floodplain depositional model for this

Figure 9. Graded stratified conglomerate in upper part of Facies C. Chert-rich pebble conglomerates occur in overlapping beds which grade to, or interbed with very coarse grained lithic arenite. Beds internally are massive or display planar and rare trough crossbed sets.

area.

Devils Claw Formation

The Devils Claw Formation makes up a minor part of the northeast map area, exposed only at in a belt northwest from the type area at Devils Claw Mountain, where it is about 300 m thick. It is described in some detail in Cookenboo and Bustin (1989) and was only examined briefly during this study. It consists of thick pebble-cobble conglomerates which occur in broad channelized layers, amalgamated or complexly overlapping in sets several tens of metres thick. The conglomerates are similar to those described above, generally subtly graded-stratified internally, including both trough and planar crossbedding, although appearing massive on weathered surfaces. They form resistant ribs with slightly irregular to channelized bases. Medium to coarse grained sandstone plus mudstone and rare coal occur between the conglomerate layers. The fluvial interpretation of Cookenboo and Bustin (1989) is supported by our observations.

MAITLAND VOLCANICS

Erosional remnants of extensive basaltic flows and volcanic necks in northwest Spatsizi map area are the remains of a Pliocene shield volcano once covering more than 900 km^2 (Souther, 1990; Evenchick and Green, 1990). Many small remnants of similar volcanic rocks, assumed to be Maitland volcanics, occur as far south as the southern border of Spatsizi map area.

An additional three outliers occur in northwest Bowser Lake area (Fig. 2). Two consist of abundant breccia, vesicular basalt, volcanogenic sediments, and well preserved pillow lava. The thickest sections are at least 100 m thick. Columnar basalt, typical of the Maitland volcanics in Spatsizi area, is absent. These outliers and the outcrops in Spatsizi map area correspond to low wavelength, high amplitude highs on the regional aeromagnetic map (Geophysical Series map 7779G, 1978). It is likely that the 2 other similar aeromagnetic anomalies in the vicinity are also Maitland volcanics.

PLUTONIC ROCKS

Poison pluton

The Poison pluton, named herein, underlies about 4 km^2 in the southeast corner of the map area, 7 km due west of Poison Mountain (GSC, 1957). It has sharp intrusive contacts with the surrounding Bowser Lake Group. The leucocratic quartz diorite or gabbro is massive, equigranular, with up to 15% hornblende, and generally less than 5% biotite. The contact aureole is characterized by an absence of cleavage in the Bowser Lake Group only within 30 m of the contact, and includes near equant porphyroblasts up to 1 mm across within 15 m of the contact. The pluton coincides roughly with one of the few distinct aeromagnetic highs within the Bowser Lake map area (Geophysical Series map 7779G, 1978; Lowe et al., 1992). Its composition contrasts with the potassium feldspar-megacrystic granodiorite to quartz monzodiorite plutons in southwest McConnell Creek and north Hazelton map areas, 30-50 km to the southeast (Richards, 1990; Evenchick and Porter, 1993).

Strohn Creek Pluton

The Strohn Creek pluton, named by Grove (1986), was first described by McConnell (1913). It intrudes the Salmon River Formation on the highway between Meziadin and Stewart. The hornblende biotite monzogranite is massive, medium grained, and contains potassium feldspar megacrysts. It is cut by local decimetre-wide granite pegmatite dykes. The pluton is locally sericitized and veined with quartz and sparse molybdenite along steep west-northwest, north-northwest and north-northeast trending joints and minor shear fractures. Its contacts are sharp and discordant to bedding and cleavage in the host Salmon River Formation. Cordierite and andalusite are conspicuous in weathered Salmon River Formation along the northern contact of the pluton.

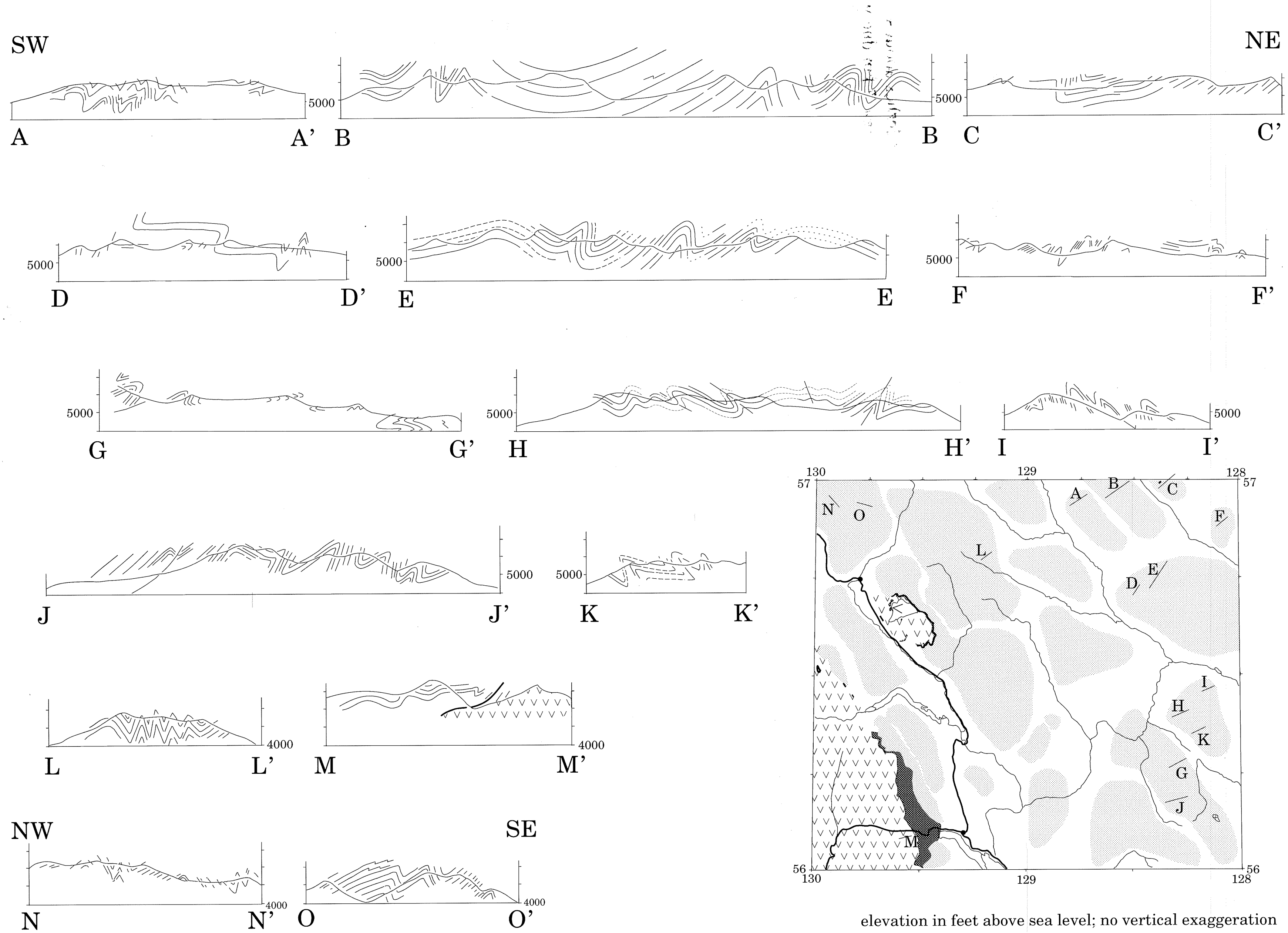


Figure 10. Cross-sections of Bowser Lake area. No vertical exaggeration.

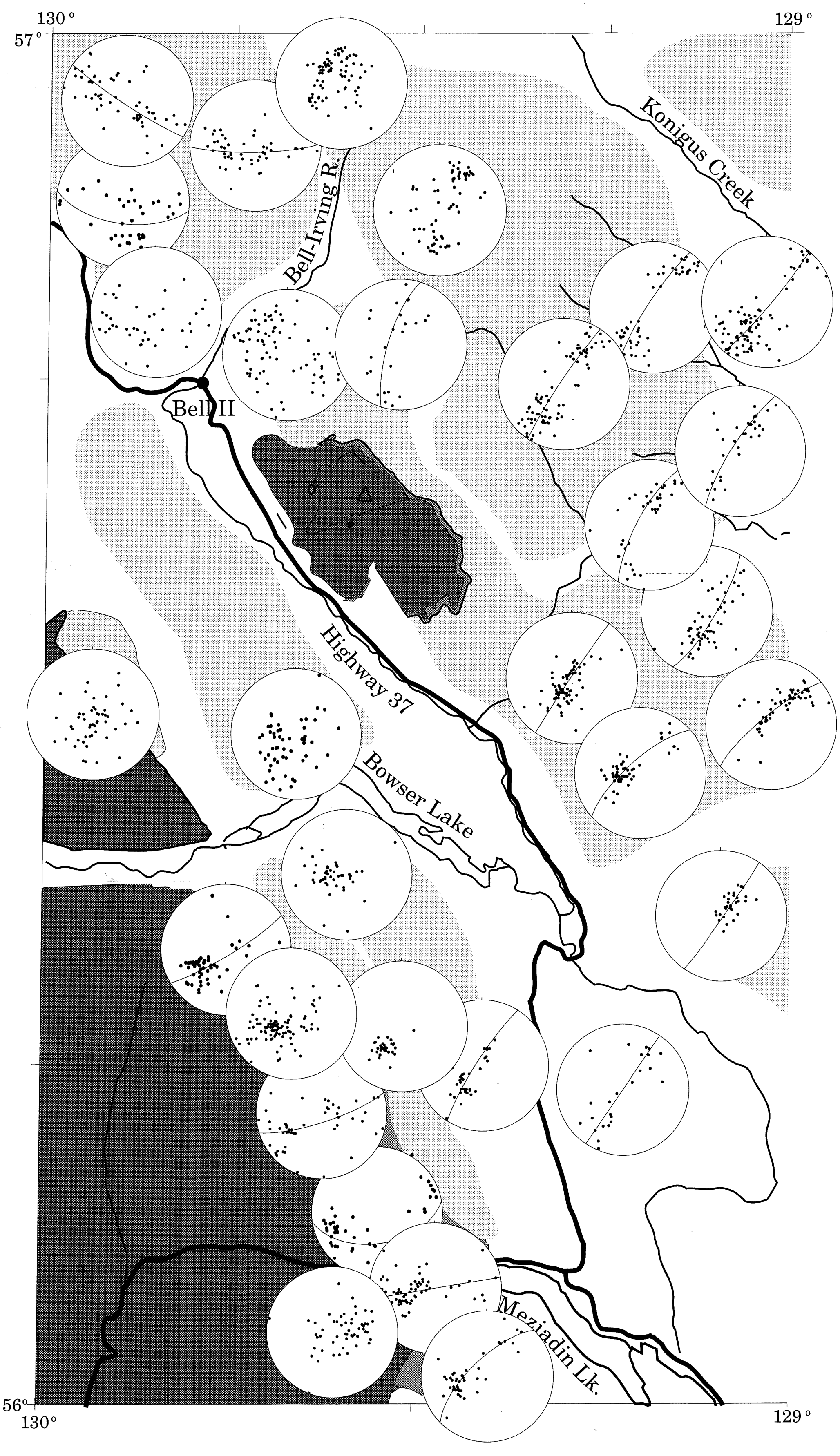


Figure 11. Lower hemisphere equal area projections of poles bedding for Bowser Lake map area.


129°
128°
57°
Nass River
eena River
Vile Ck.
Nass River
0 km 10
129°
56°
128°

STRUCTURAL GEOLOGY

All strata in the area are intensely deformed by folds and faults. The general geometry of folds is characterized in cross-sections (Fig. 10) and stereonets of poles to bedding (Fig. 11). Cleavage varies from intense to absent. North-northwest and northwest-trending folds dominate (Fig. 11). North of Bell II, however, folds trend north to northeast, consistent with those in southwest Spatsizi area (Evenchick and Green, 1990). Folds vary widely in geometry, from open, rounded, to box folds, to tight chevron folds (e.g., Fig. 12), they are similar to folds farther north in the Skeena Fold Belt (Evenchick, 1991b).

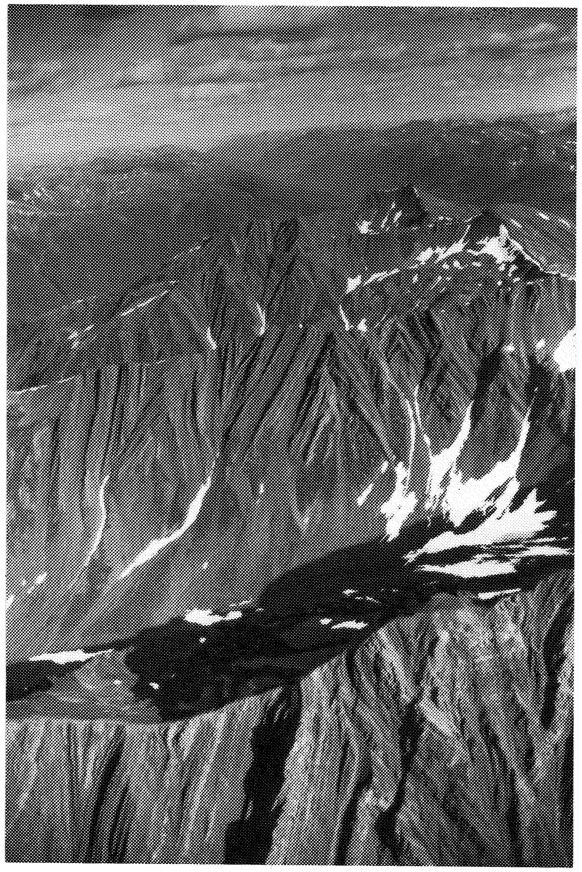


Figure 12. Upright chevron folds at head of Muskaboo Creek. View to southeast.

Fold orientation also varies widely, from upright to recumbent. An entire range southwest of Vile Creek is characterized by steeply overturned to recumbent folds (e.g., Fig. 13, Fig. 10, section GG'). Elsewhere, recumbent folds are uncommon. Fold plunge is generally less than 10°. Folds verge dominantly northeast (Fig. 10), although some domains of southwest vergence are present, for example, northeast of Vile Creek (Fig. 10, sections HH', II'). Folds are generally less than several 100 m's in wavelength. An exception is the Beirnes syncline in the northeast, which is about 4 km in wavelength. Its style is controlled by the thick, competent units of chert-pebble conglomerate. Folds southeast of Oweegee dome up to 2 km in wavelength may reflect proximity to competent volcanic basement, as illustrated in Spatsizi map area (Evenchick, 1991b). Faults are uncommon, although the style of folding demands that they be common. One thrust fault southwest of Vile Creek can be mapped for several kilometres.

Figure 13. Recumbent tight to isoclinal fold southwest of Vile Creek. Width of ridge in foreground is 2.5 km. Viewed to northwest.

A prominent structural culmination called Oweegee dome exposes pre-Bowser Lake Group strata southeast of Bell II. Interpretation of the structural relationships of this area will be reported by C.J. Greig. A larger culmination has resulted in the present erosional western "margin" to the Bowser Basin. In general, volcanic rocks in the southwest map area are overlain by a monoclinal succession of Salmon River Formation with minor folds, gradationally overlain by Bowser Lake Group. Penetrative cleavage and low greenschist facies metamorphism in the lowest strata suggest that these rocks were more deeply buried than those farther east.

Structures are generally similar to those described farther north (Evenchick, 1991b). A notable difference is the presence of local large scale recumbent folds. It is likely that the degree of shortening is also similar to farther north, probably in excess of 50%. Normal faults may be present, but no significant ones were recognized in our regional mapping. The valley of the Bell-Irving River north of Bell II is the site of an apparent rapid facies change from very shallow marine and nonmarine to turbidites, as well as the location of the change from north to northwest trending folds. The zone is delineated on Figure 11 by random bedding distribution. This valley could be the locus of complex basement structures causing rapid change in structural level, expressed by a dramatic facies change, and resulting in complex folds in overlying strata.

Implications of structural style on interpretation of facies distribution

From Figure 10 it is interesting to note that although folds verge northeast, they do not result in rapid, or even moderate structural relief across trend. This might suggest that although the facies have been shortened considerably horizontally, the stratigraphic relief may not be large. Similarly, the gentle plunge is not expected to produce significant structural relief (and therefore stratigraphic relief) along trend, so the northwest trend of facies belts may reflect generally the primary basin architecture. Similar arguments may be used to infer that the very shallow marine strata in the belt of turbidites northeast of Meziadin Lake represents either a primary basin high, or the area is bounded by unrecognized normal faults. An obvious exception to this treatment is Oweegee dome, where rocks as old as Devonian are exposed (Greig, 1991, 1992).

The belt of Facies A turbidites are interpreted as a western "distal" facies derived from the northeast, with the abundance of chert clasts identifying the Cache Creek Terrane as the primary source area (Souther and Armstrong, 1966). The occurrence of Facies A west of the extensive region of Facies B shallow marine strata could reflect an original facies transition of broadly coeval sediments. Alternately, the facies belts may be different ages, with Facies B stratigraphically higher than Facies A. The most likely situation is a combination of both scenarios, with facies boundaries generally moving southwest with time as the basin filled. The extent of overlap of the facies ages is unknown, pending identification of collected fossils.

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