Marine Environments of the Upper Cretaceous Nanaimo Group, Pender Island, BC
(from GAC Field Trip run by Peter Mustard, May, 1999)

Abstract: The Nanaimo Group comprises up to 4 km of sedimentary rock of Turonian to Maastrichtian age, forming the lower part of the Late Cretaceous to Neogene Georgia Basin of southwest British Columbia. This Upper Cretaceous succession was deposited in a single elongate basin deformed by Eocene compression into a fold and thrust belt. Eleven formations are recognized, comprising conformable and laterally intertonguing successions with sandstone-conglomerate units separated by mudstone and fine grained sandstone formations. Initial alluvial and coastal marine deposits formed on a rugged unconformity. Coal-bearing facies formed in coastal and marginal marine back-barrier environments, associated with fluvial and shallow marine facies. Most of the Nanaimo Group was deposited in marine, generally outer neritic to bathyal depths, by gravity flows and generally as submarine fan deposystems. Initial detritus was from local basement, but most sediment came from the Coast Belt to the east and northwest Cascades, although by latest Cretaceous time the eastern Cordillera was also a source. A forearc basin setting for the Nanaimo Group is only correct in that deposition occurred oceanward of a partly coeval magmatic arc. A foreland basin model is preferred because basin initiation and sedimentation was a direct result of contemporaneous thrusting in the Coast Belt and north Cascades. Nanaimo Group coal resources were historically important, but are now exhausted in most areas. Kaolin-rich deposits on the unconformity may be economically viable. Oil and gas potential is poor, although coalbed methane could be locally present.

Introduction

Pender Island contains extensive coastal exposures of the upper Cretaceous Nanaimo Group, lacking only the basal and top units of this 4 km+ thick succession. Stops have been selected to provide a range of sedimentary features rather then to illustrate the evolution of the Nanaimo Group, although coincidentally the order of outcrops viewed are in proper stratigraphic position from youngest to oldest (early to late Campanian). Coarse conglomerates of both shallow shelf (coastal fan?) and probably deep shelf-slope marine environments contrast with massive mudstone and classical sandstone-mudstone turbidites. The dominant depositional process is sediment gravity flow, with a variety of flow types, dewatering and synsedimentary deformation features preserved. Several figures are included on facing pages to the stop text which should aid in identifying or interpreting the features of these sedimentary facies.

Regional Setting

The Nanaimo Group was deposited in the Nanaimo Basin, a northwest-trending structural and topographic depression which includes Georgia Strait, eastern Vancouver Island, the Fraser River lowlands of British Columbia, and northwest Washington State. The present basin is an erosional remnant and its configuration is largely the result of post-depositional deformation. For much of its depositional history the basin appears to have extended considerably farther to the west.

The main structural control on the sub-Nanaimo Group rocks and to some extent the Nanaimo Basin itself is southwest- to west-vergent thrusting that took place from late Jurassic

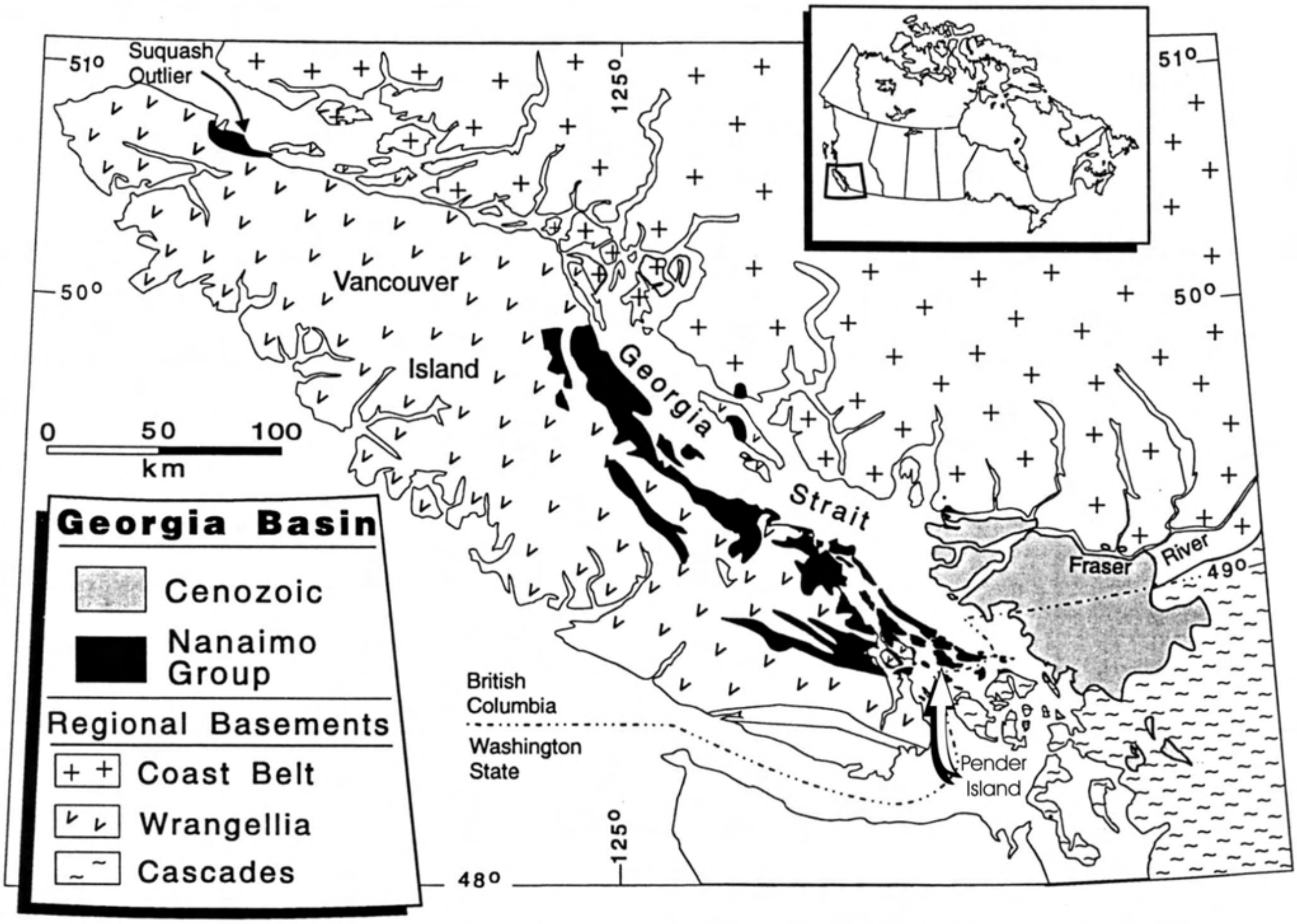


Figure 1. Regional setting of Georgia Basin, with the upper Cretaceous Nanaimo Group shown in dark grey.

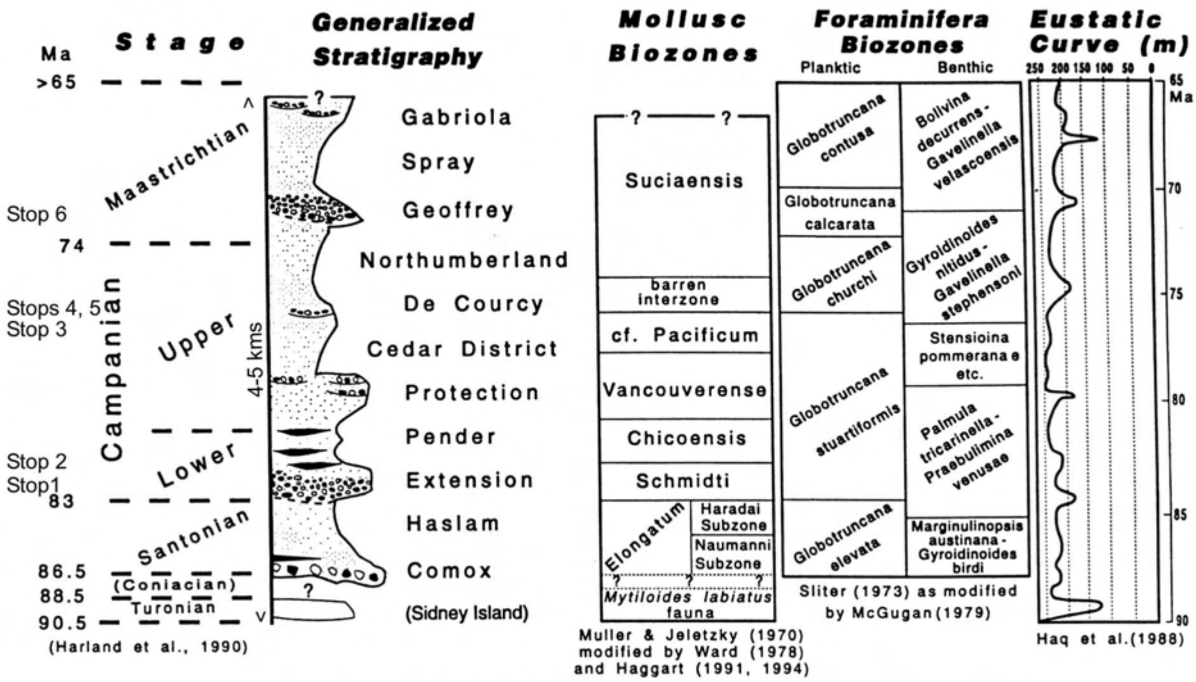


Figure 4. General stratigraphy of the Nanaimo Group showing the most recent biostratigraphic zonations based on molluscan and foraminifera fossils. The time scale used here and in text is from Harland et al. (1990); note that stage boundary age values have margins of error ranging from 2 to 3.6 million years, formations are diachronous laterally, and the upper age of the Gabriola Formation is not well constrained. Eustatic sea level variations as suggested by Haq et al. (1988) are shown at right.

to Holocene time as a response to underthrusting of the Farallon/Kula (now Juan De Fuca) oceanic plate beneath the North American plate. A mid to late Cretaceous west-vergent thrust system is preserved at the southern margin of the Nanaimo Basin (Brandon *et al.*, 1988) and in the eastern Coast Belt (Journeay, et. al, 1992; Monger and Journeay 1994). The basin has also been deformed into a fold and thrust belt during early Tertiary compression which resulted in southwest directed thrusting (England and Calon, 1991, but see Journeay and Morrison, 1999 for a new, alternate view on the deformation).

The Nanaimo Group comprises more than 4 km of sedimentary rocks of Turonian to Maastrichtian age. The strata are commonly subdivided into eleven formations (although different stratigraphic schemes have been proposed) comprising conglomerate, sandstone, and mudstone, with significant coal deposits in the lower formations. In the southern Gulf Islands all but the basal Nanaimo Group consists of marine sandstone-conglomerate successions separated by thick packages of mudstone and fine-grained sandstone. These occur as sedimentary sequences hundreds of metres to more than a kilometre thick in some places. Internal lateral and vertical thickness and facies variations are common, with both coarsening and fining-upward trends evident on several scales. Formation boundaries are conformable and commonly gradational, but dramatic facies changes have caused locally sharp and erosive contacts which some workers interpreted as unconformities, although no major biostratigraphic gaps are apparent.

Sedimentologic interpretations prior to the 1980's suggested fluvial and deltaic models for most Nanaimo Group sedimentation, interpreting the extensive laminated and thin-bedded mudstone-sandstone facies as prodelta shelf deposits and sandstone-conglomerate facies as fluvial or proximal deltaic deposits (eg. Muller and Jeletzky, 1970, Hudson, 1974 for Pender Island specifically). Researchers in the 1980's, aided by the explosion of literature on deeper water environments and increasing amounts of paleontologic data from specific formations, reinterpreted most of the Nanaimo Group outside of the coal-bearing areas (Nanaimo and Comox areas of Vancouver Island) as submarine fan deposits in deep shelf and slope areas (eg. Ward and Stanley, 1982; Pacht, 1984, England, 1990). Exceptions include the basal Comox (Benson) Formation, a coarse-conglomerate and sandstone unit which is mostly alluvial non-marine or shllow marine; and possible coastal or shallow marine fan-delta deposits of the Extension Formation in the southeast part of the basin (south Pender Island and the San Juan Islands; e.g. Stop 1).

Most researchers have suggested the Nanaimo Group was deposited in a forearc basin (Muller and Jeletzky, 1970, Ward and Stanley, 1982, England, 1990). A strike-slip basin model was suggested by Pacht (1984), but faults interpreted by him as synsedimentary and strike-slip

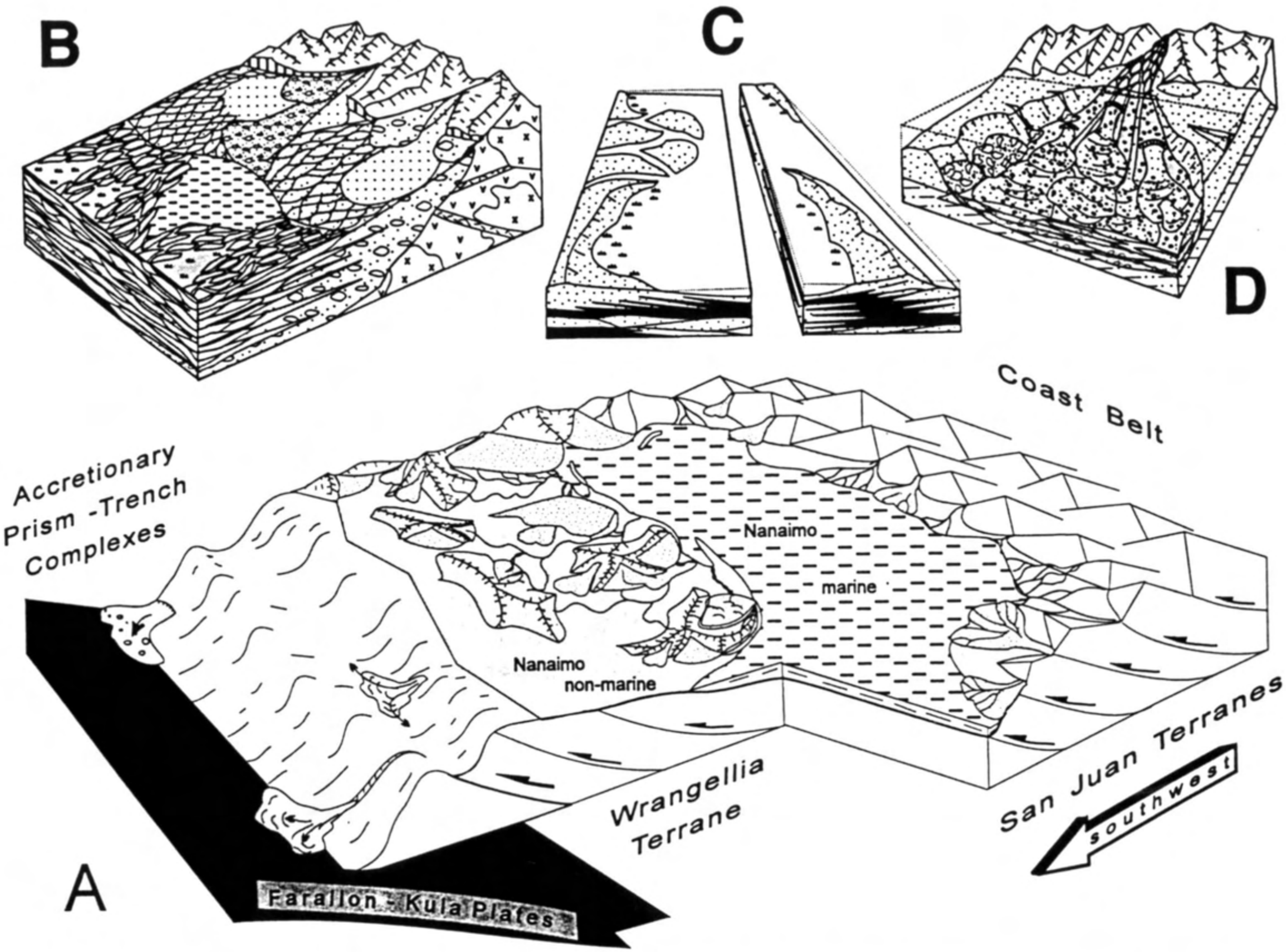
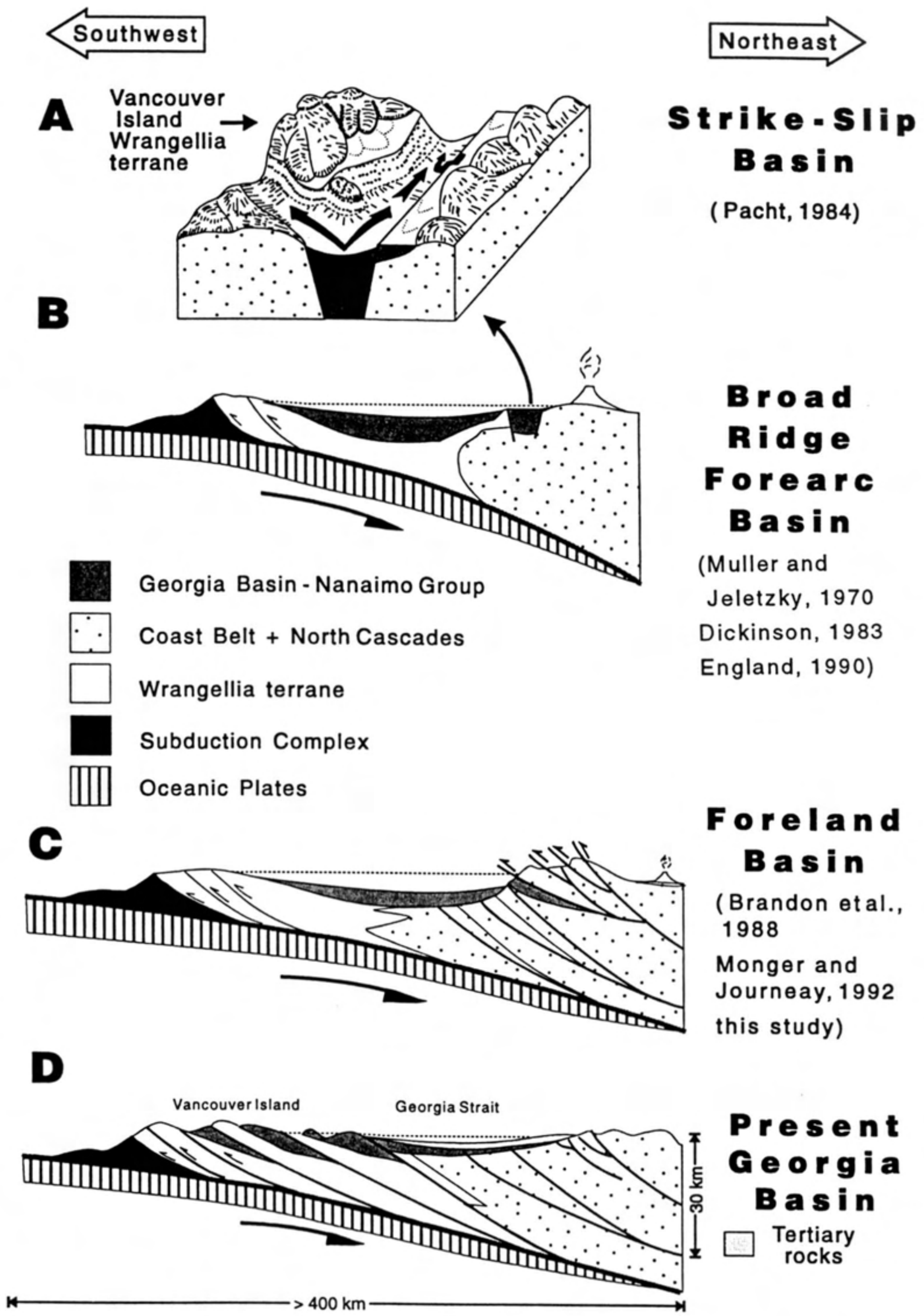


Figure 6. ***A)*** *Schematic representation of early Nanaimo Group depositional basin setting within southwest British Columbia.* ***B)*** *Example of a nonmarine alluvial fan and braidplain model, including possible abandoned braid belt swamps where some of the Comox Formation coals may have formed (modified from Wu Chonglong et al., 1992).* ***C)*** *Deltaic and back-barrier depositional environments envisioned for much of the coal- bearing Nanaimo Group (e.g., upper Comox Formation in Comox outcrop area; parts of Extension, Pender, and lower Protection formations in northern Nanaimo outcrop area) (modified from Nemec, 1992).* ***D)*** *Coarse grained fan delta deposystem showing subaerial to subaqueous transition without coastal distributary plain (modified from Nemec, 1992).*

have since been shown to be post-deposition thrusts (England and Calon, 1991). A foreland basin model was proposed by Brandon et al, (1988) on the basis of late Cretaceous thrusting he recognised in the San Juan Islands. Support for this foreland basin model comes from a re-examination of the pattern of regional basin fill (Mustard, 1991, 1994, Mustard et al., 1995) and the recognition that Late Cretaceous southwest-vergent thrusting in the Coast Belt east of the Georgia Basin includes thrusts active during Nanaimo Group sedimentation (Journeay *et al,* 1992, Monger and Journeay, 1994).

The most recent controversy which includes the Nanaimo Group is the paleolatitude of the Insular Superterrane and related rocks during the Late Cretaceous. Several paleomagnetic studies have been interpreted to suggest that the Insular Superterrane was >3000 km south of present position in the late Cretaceous and reached about present position by about 50 Ma (this is generally termed the "Baja B.C." hypothesis). The latest paleomagnetic study to suggest this was conducted in the Nanaimo Group by Ward *et al.,* (1997), who sampled mid and upper Nanaimo Group strata on Hornby and Texada Island. This study is extremely significant for two reasons: 1) the paleomagnetic results from it suggest the furthest south paleolatitude of any Insular Superterrane study (about 3500 km or 25 +/- 3° N latitude in late Cretaceous latitudinal reference; 2) the age of the strata sampled is mid to late Campanian (about 76-72 Ma), which constrains the timing of movement of "Baja B.C." much more tightly than previous estimates of 90-50 Ma (now about 74-50 Ma). However, the paleomagnetic evidence is not compatible with geologic evidence for the paleoposition of the Insular Superterrane, including the Nanaimo Basin (which is strictly speaking an overlap assemblage to the superterrane and not part of the terrane itself). Know fault relationships and motions, correlation of lithostratigraphic units, paleontologic studies and sedimentologic studies from various parts of the disputed area all conflict to some extent with the "Baja B.C." hypothesis. Most recently; detailed detrital zircon studies from the Nanaimo, Queen Charlotte and Methow basins all suggest that the source areas for Precambrian zircons found in these basins must have been southeast British Columbia or eastern Washington / western Idaho rocks of the Windermere and Belt/Purcell Supergroups (Mahoney *et al.*, 1999). This strongly indicates that these basins (and their Insular Superterrane basements) must have been in northern positions during the entire late Cretaceous, fundamentally questioning the validity of the "Baja B.C." hypothesis.



A) Strike-slip basin setting as proposed by Pacht (1980, 1984) which he suggested formed as a small basin in a larger forearc setting (shown with arrow from Fig. B) or as a separate pull-apart in a transpressive plate margin setting. Diagram is modified slightly from Pacht (1980).

B) Forearc basin setting proposed by several authors.

C) Foreland basin setting proposed here.

D) Schematic of present Georgia Basin illustrating preservation of remnants of the originally more extensive Nanaimo Group strata as thrust slices in a west-vergent fold and thrust belt (probably formed during Eocene transpression).

Figure 17. *Schematic illustrations of different tectonic settings proposed for the Nanaimo Group.*

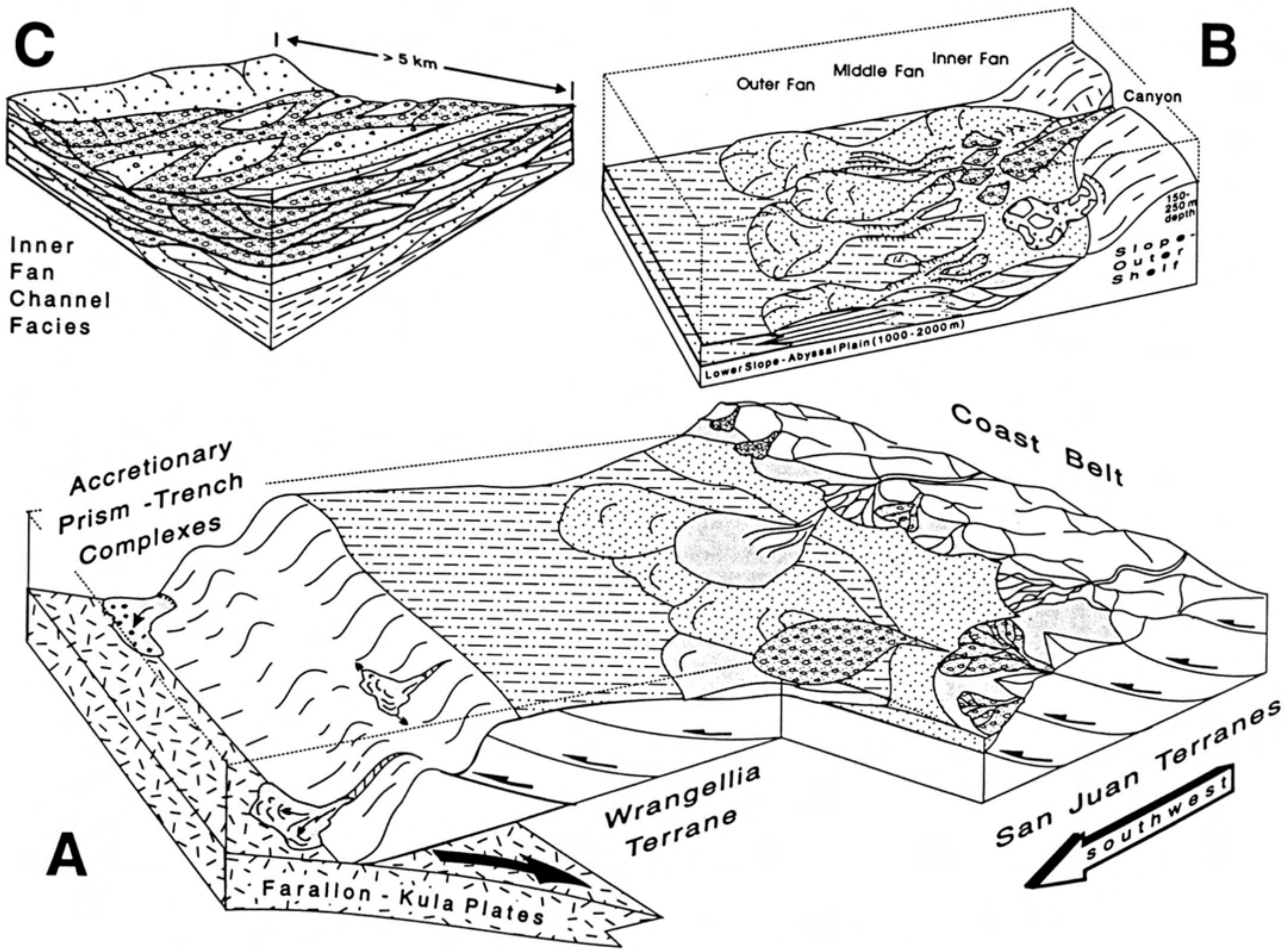


Figure 9. ***A)*** *Schematic representation of Nanaimo Group basin during marine dominated deposition.* ***B)*** *Example of radial submarine fan sedimentation model envisioned for Nanaimo Group (modified from Shanmugam and Moiola, 1988).* ***C)*** *Example of inner fan channel facies environment (modified from Pickering et al., 1989).*

Field Trip Stops

The six stops were selected on the basis of easy accessibility and to provide a range of both typical and unusual features of the Nanaimo Group in this area. The descriptions for the stops are condensed from the publications of Hudson (1974, an M.Sc. thesis on Pender Island); Ward (1978, a revision of Nanaimo Group stratigraphy and biochronology in which the Pender Formation is defined with a type area which includes Stop 2); Pacht (1980 a PhD thesis on the southern part of the Nanaimo Group), and England (1990a; a PhD thesis on the entire Nanaimo Group, and 1990b, an unpublished Nanaimo Group field trip guide produced for the 1990 GAC annual meeting). The author has supplanted these descriptions with his own observations and diagrams where possible.

Extension Formation

Location: bay 200 m east of Tilley Point, south tip of South Pender

Access: beach access stairs at south end of Craddock Drive

Age: early Campanian (Schmidti fossil zone)

The Extension Formation comprises conglomerate and coarse-grained sandstone with minor mudstone and a coal-bearing facies restricted to the Nanaimo area. The formation thins from about 500 m in the south Gulf Islands to 100-200 m in the Nanaimo area. Thick-bedded pebble-boulder conglomerate is typical, generally poorly organized in overlapping sheets or lens with interbeds of medium- to coarse-grained lithic or arkosic arenite, all commonly with calcareous cement. Most conglomerates are massive and non-graded, but graded-stratified types occur and planar crossbed sets are preserved in some places. The Extension Formation overlies Haslam Formation turbidite sandstone-mudstone with a gradational or in places sharp contact and gradationally changes to the marine mudstone of the overlying Pender Formation (Stop 2). Fossils are rare, but shallow marine bivalves are locally abundant. Paleocurrents flowed west or northwest. Conglomerate clasts include mafic volcanics, chert, granitic, metamorphic and metasedimentary types. The northwest thinning trend, paleocurrents and clast types suggest the major source area was the San Juan thrust belt and Cascades to the southeast and the Coast belt to the east. Recent workers have interpreted most of the Extension Formation as the inner fan facies of submarine fan systems. However fluvial-deltaic and shallow marine interpretations are retained for the Nanaimo area and exposures on the San Juan Islands (and perhaps here?).

Stop 1 is near the base of the Extension Formation, which Pacht (1980) measured as 480 m thick here (thrust-repeated, so thinner, but still probably the thickest preserved section in the basin). The rocks at stop 1 are predominantly red brown clast-supported conglomerates in a coarse-grained, red, lithic arenite matrix. The lower conglomerate (west of access stairs) are typically disorganised and massive, occurring in complexly overlapping sheets and lenses about .5 to > 2 m thick, with irregular, loaded but generally non-erosive contacts, although slight scour is apparent into the rare pebbly sandstone interbeds. Grading if present is poorly developed inverse or normal. Clasts are generally subround and subspherical, with up to 20% sandstone or siltstone ripups. The conglomerates east of the access stairs are slightly better organized with normal grading more common and internal stratification in some. Bed are typically .5-1.5 m thick lens or broad sheets with loaded and curved lower contacts which in some places erode slightly into underlying beds. Planar crossbedded conglomerates occur in 1-2 m thick sets and indicate northwest paleoflow. Interbeds of fine-grained sandstone and silty mudstone are present. The mudstone is massive but mottled, and common trace fossils in some suggest that bioturbation accounts for the lack of internal structures.

Depositional environment interpretations vary for the Extension Formation in this area. Hudson (1974) suggested the Extension Formation here is a fluvial deposit with a nearby source. Ward and Stanley (1980) and Pacht (1984) suggested the Extension conglomerates were deposited in the inner fan or submarine canyon part of deep water submarine fan systems. England (1990) interprets this area as in a shallow shelf setting at this time, but also refers to the South Pender conglomerates as an example of a braided stream fluvial facies!!

Extension & Pender Formations

Location: Boat Nook, southwest coast of North Pender
Access: beach access path between houses, Schooner Way
Age: early Campanian (Chicoensis fossil zone)

The Pender Formation was named by Ward (1978) for a regionally persistent unit of thin-bedded mudstone, siltstone and fine-grained sandstone which conformably separates the conglomerates and coarser sandstones of the underlying Extension and overlying Protection Formations. The Pender Formation varies in thickness between about 100 and 300 m and is about 150 m thick at the type section (Stop 2 includes the base of that section). In the Nanaimo area the Pender Formation includes pebbly sandstones and significant coal seams, but south of that area is dominated by massive mudstone and sandstone-mudstone interbeds containing "classic" turbidite features. The formation is abundantly fossiliferous in places, with a variety of molluscan fauna, including index fossils of the Chicoensis biozone (late early Campanian age) and a rich foraminifera assemblage . The Pender Formation in the Nanaimo area is interpreted by most workers as a coastal plain and fluvial deltaic deposit with minor marine tongues. Outside of this area early workers considered the Pender Formation to be a prodelta marine shelf deposit. England (1990) reports paleodepth indications from forams to be in the outer shelf to mid-slope range (150-1200 m) for most of the formation and considered the Pender Island strata to be outer shelf. He suggested the massive mudstone was deposited as low energy shelf/slope deposits and the interbedded sandstone-mudstone couplets represent deep prodelta or interchannel turbidites. Pacht (1984) considered most of the Pender Formation to be relatively deep marine, but the Pender Island area and south to be in a shallow or marginal marine environment.

At Boat Nook the upper Extension Formation is in gradational contact with the basal Pender Formation. Extension Formation fine- to coarse-grained sandstone thin to thick beds and pebble-granule conglomerate beds and lens are interbedded with massive and faintly laminated mudstone over an interval of several tens of metres. Some conglomerate are normally graded and stratified and sandstone are rarely cross-stratified. This is overlain by massive mudstone with rare discontinuous fine sandstone and siltstone interbeds and concretionary lens. Mottling in the massive mudstone and abundant burrows preserved in the concretionary lens suggest significant bioturbation. Shell fragments are common, some occurring as discontinuous coquinas.

Above this exposure the Pender Formation coarsens and thickens upward overall (but with several smaller cycles) with fine-grained sandstone turbidites increasingly common, gradationally overlain by thick-bedded massive and graded sandstones of the lower Protection Formation. England (1990) suggests foraminifera from the Pender Formation at Boat Nook indicate water depths of >150 m. A suggested interpretation for the Extension-Pender transition is a gradual change from pro-delta or fan collapse sand-gravel sediment gravity flows to a quieter water environment dominated by mud deposition. This could reflect a relative rise in sea level, migration of the fan system away from the area, or lessening input of coarse clastics into the basin, perhaps due to changing tectonic conditions.

Cedar District & De Courcy Formations

Location: northeast Medicine Beach, Bedwell Hbr, North Pender

Access: beach road southeast of east end Schooner Way

Age: late Campanian (Vancouverense and Pacificum fossil zones)

The Cedar District Formation is a thick succession of interbedded mudstone and sandstone (generally arkosic wacke) which overlies the sandstone-conglomerate Protection Formation and is in turn overlain by thick-bedded sandstones of the De Courcy Formation. Both the basal and top contacts are gradational and complexly interfingering. Thicknesses vary from about 300 m in the Nanaimo area to about 500 m in the south Gulf Islands. The formation generally changes from lower massive and laminated mudstone and less common fine-grained sandstone and siltstone thin beds to an upper part in which sandstone thin and medium beds are common, an overall coarsening upward trend, although only on the scale of the entire formation. Sandstone-mudstone couplets display a range of Bouma turbidite sedimentary structures. Most beds are laterally continuous over 100's of metres and soft sediment deformation and dewatering structures are well developed in some places. Macrofossils are locally abundant and include ammonites and inocerimids indicating a late Campanian age. Foraminifera are common and diverse and have been interpreted to indicate relatively deep water deposition (200-600 m) with down-slope transport of shallow water types (Cameron, 1988; cited in England, 1990). Early authors interpreted this formation in terms of pro-delta marine shelf deposition. More recent interpretations invoked deep shelf or slope submarine fan models (Pacht, 1980, 1984; England, 1990). Pacht (1980, 1984) suggested the sandstone compositions reflect derivation mostly from the Coast Belt with a lessor amount of Cascades detritus. Paleocurrents are generally oriented northwest-southeast, but this may be along the basin axis rather then reflecting paleoflow perpendicular to source areas.

At Medicine Beach the upper 80 m of the Cedar District Formation is well exposed. Sandstone and mudstone couplets show about a 1:1 sand-mud ratio, although this varies in the section. Bouma sequence Tbce, Tae, Tbc and Tbcde are common. Sandstone beds are generally <10 cm thick, but rare beds up to 40 cm thick are present. Most beds appear laterally continuous, but some pinch out laterally and can be seen to occupy very broad channels. Both fining/thinning and coarsening/thickening trends on the scale of a few metres can be "defined", although the definition may differ for different observers. It does appear that the upper part of the section has increasingly common thick beds of sandstone and rare coarse-grained to granule beds. The contact with the De Courcy Formation is placed at the base of the abundant thick-bedded sandstones at the north end of the exposure. Although a regular coarsening upward trend to this contact is not obvious there is an overall increase in sandstone thickness and grain size, suggesting a gradational rather than sharp contact (the latter proposed by early workers). The change to thick-bedded sandstone may represent migration of mid to upper submarine fan facies over the mid to lower fan facies of the underlying unit.

Stop 5 De Courcy Formation

Location: north of Willey Point, northwest coast of North Pender

Access: stairs at end of Bridges Road, off Stanley Point Road

Age: late Campanian (between Pacificum & Suciaensis fossil zones)

This stop is in the central to upper part of the De Courcy Formation. The De Courcy on this coast is slightly atypical in that several unusually thick layers (10's of metres) of thin-bedded sandstone-mudstone classical turbidites separate the more typical thick-bedded sandstones. This may represent migration of fan lobes on the larger fan complex(?). Two interesting features are apparent at this stop. The strata below the lowest thick-bedded sandstone displays a several metre thick interval of synsedimentary folding with more folds and small clastic dykes present a few metres lower in the section. Synsedimentary folds and small thrusts have been reported from several parts of the De Courcy Formation, and occur in several other units of the Nanaimo Group as well. Muller and Jeletzky (1970) report several occurrences of these features in the De Courcy (however, this outcrop has not been noted by any previous workers). They suggested a northeast to northwest dipping paleoslope based on the sense of deformation.

The other obvious feature here is a sedimentary float-breccia about 30 m thick, with abundant sedimentary blocks in a matrix which changes from sand-rich to mud-rich upward. The upper contact with the overlying sandstone thick bed is extremely irregular, suggesting the mud matrix was water rich when the overlying sand flow was deposited. Many of the blocks within the thick debris flow are internally deformed, indicating they were not completely indurated when incorporated. A shelf collapse or slope slump origin is proposed for this feature. Such a large failure could represent seismic activity, sea-level changes or oversteepening of slopes due to progradation of fan lobes (?). This is the best example I've seen, but such sedimentary breccia flows are present in most of the submarine fan units of the Nanaimo Group.

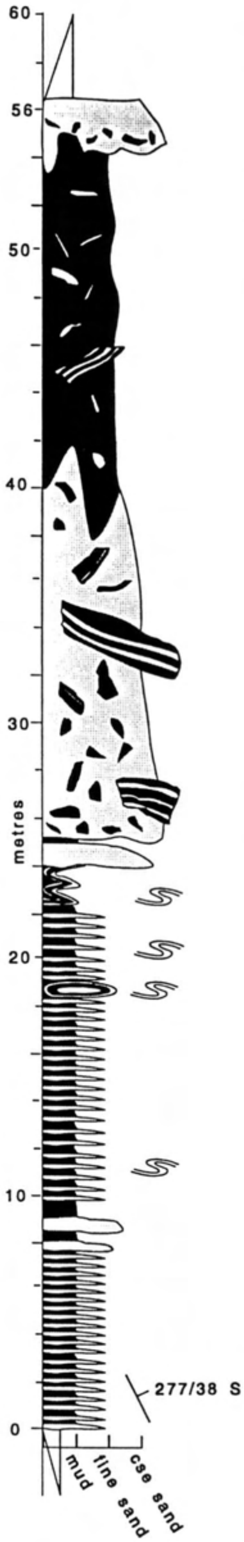


Figure 13. Measured section through sedimentary breccia exposed in the central to upper De Courcy Formation on the northwest coast of North Pender Island. This 30 m thick sedimentary float-breccia comprises abundant angular sedimentary blocks in a matrix which changes upward from sand-rich to mud-rich. The upper contact with the overlying sandstone thick bed is extremely irregular, suggesting the mud matrix was water-rich when the overlying sand flow was deposited. Many of the blocks within the thick debris flow are internally deformed, indicating they were not completely indurated when incorporated. A shelf slope or canyon wall collapse origin is proposed for this feature. The section of mudstone-sandstone thin beds below the breccia unit contains several examples of synsedimentary folds (including spectacular sheath folds) and small clastic dykes. The sense of deformation on these folds suggests a northwest-dipping paleoslope for this area.

Geoffrey (Galiano) Formation

Location: south of James Point, northwest coast of North Pender

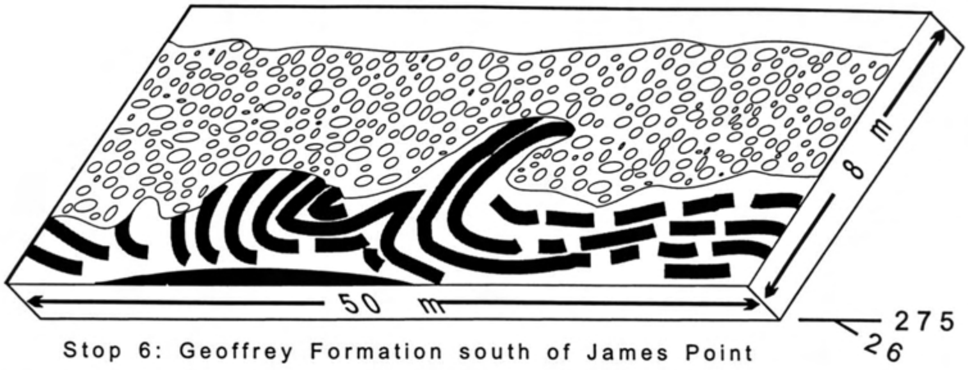
Access: south at stairs near west end of Mackinnon Road

Age: late Campanian - early Maastrichtian (Suciaensis fossil zone)

The Geoffrey Formation occurs on the outer Gulf Islands and forms spectacular cliffs of conglomerate on Mayne, Galiano and Hornby Islands. It varies from about 150 to 550 m in thickness. The basal contact with the underlying Northumberland Formation is generally sharp in areas of thick conglomerates and gradational where sandstone is the main Geoffrey rock type. The top contact is generally gradational into the mudstone-sandstone turbidites of the overlying Spray Formation. Thick bedded pebble-cobble conglomerates occur as complexly overlapping lenses and sheets in large channel sets which erode several metres into underlying beds. These are contained in several hundred metre thick units of conglomerate and minor coarse-grained sandstone (well exposed in Active Pass on Galiano Island). The conglomerates are massive, displaying graded and non-graded types and rarely poorly imbricated at the base. Clasts are generally subround to round with felsic plutonic, mafic volcanic and chert as the main clast compositions. Laterally these thick conglomerate-dominant areas gradationally change to areas of thick-bedded, coarse-grained sandstone with less common individual or thin (<10 m) amalgamated sets of conglomerate lens and sheets. Fine-grained sandstone and mudstone as thin-bedded couplets occur as decimeter thick successions in some places between the coarser units. The thick-bedded sandstones are generally massive coarse-grained arkosic arenite or wacke showing the same geometries and structures as described for the De Courcy Formation. Trace fossils and rare bivalves occur in the finer sandstone-mudstone interbeds.

Early interpretations of the depositional environment proposed fluvial and deltaic models. A more likely interpretation suggested by England (1990) is that the Geoffrey represents a major influx of coarse detritus to the basin through several submarine channel systems (the conglomerate-dominate areas) into coarse upper submarine fan complexes (the sandstone-dominant areas). As for the De Courcy Formation, the sandstone compositions suggest a source from the Coast Belt plutonic rocks (Pacht 1984, Mustard, 1994, Mustard *et al.*, 1995)).

Stop 6 is in the upper Geoffrey Formation and comprises several packages of thick-bedded sandstones with irregular conglomerate lenses and sheets separated by small recessive bays which probably contain mudstone and finer sandstone thin beds. At the south end of the first bay a 2 m thick package of medium to coarse-grained sandstone beds has been folded and deformed, presumably by the deposition of the overlying cobble-pebble conglomerate bed. The extreme loading and injection structures are well displayed and appear to indicate a westerly paleoslope here. Higher units show a complex interbedding of sandstones and pebble-cobble conglomerate lenses.



Stop 6: Geoffrey Formation south of James Point

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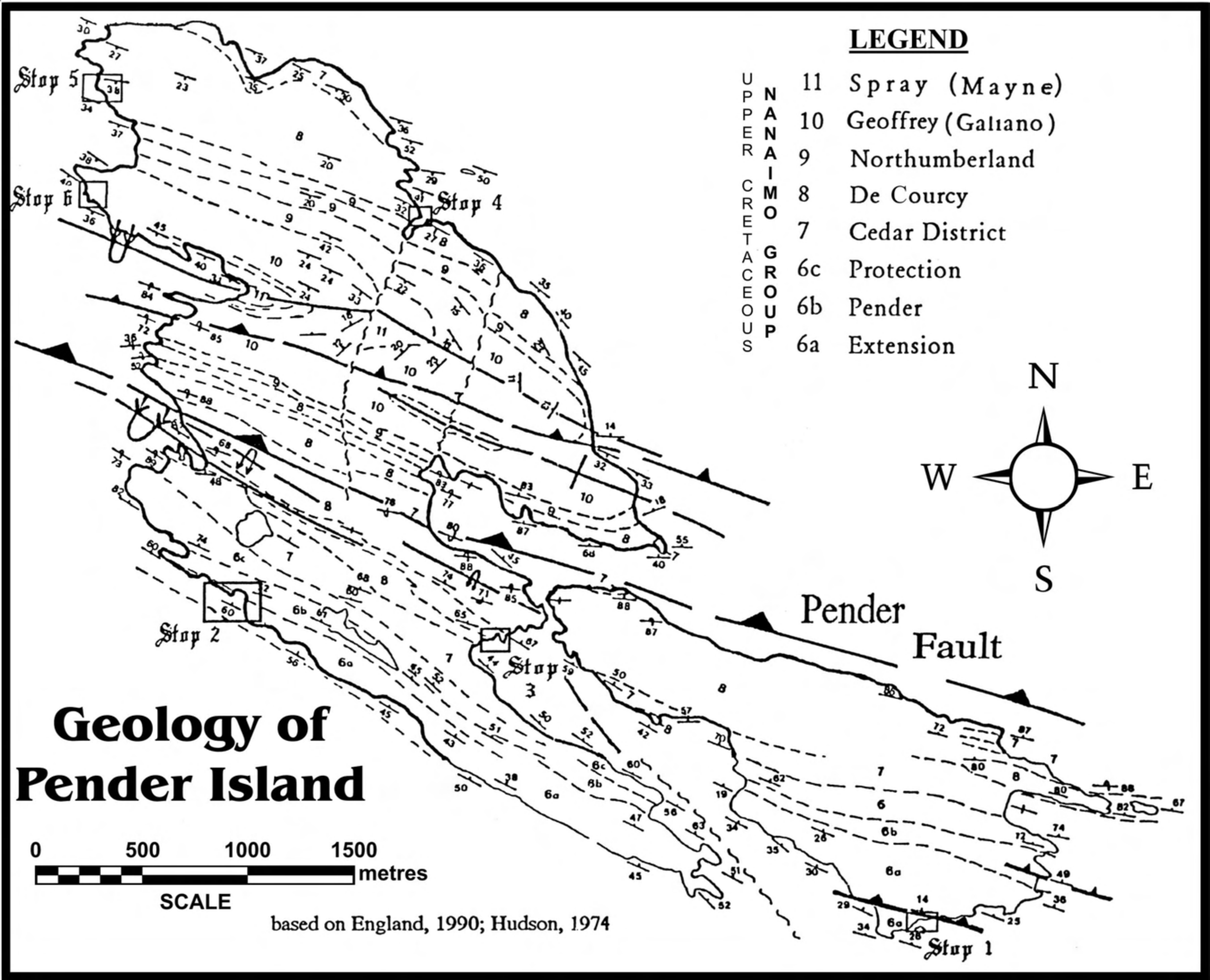
LEGEND
UPPER CRETACEOUS
NANAIMO GROUP
11 Spray (Mayne)
10 Geoffrey (Galiano)
9 Northumberland
8 De Courcy
7 Cedar District
6c Protection
6b Pender
6a Extension
N
W
E
S
Pender Fault
Stop 1
Stop 2
Stop 3
Stop 4
Stop 5
Stop 6
Geology of Pender Island
0 500 1000 1500
metres
SCALE
based on England, 1990; Hudson, 1974