Nanaimo Geotour 2015

A collaboration of MineralsEd and University of Vancouver Island Earth Science Department
in support of Nanaimo area teachers
on the Provincial Professional Development Day, Oct. 23, 2015

Led by

Dr. Jerome Lesemann, VIU Earth Science

VANCOUVER ISLAND UNIVERSITY

mineralsed
Mineral Resources Education Program of BC

Eon	Era	Period	Epoch	m.y.
Phanerozoic	Cenozoic	Quaternary	Holocene	
			Pleistocene	1.5
		Neogene	Pliocene	
			Miocene	23
		Paleogene	Oligocene	
			Eocene	
			Paleocene	65
	Mesozoic	Cretaceous		
		Jurassic		
		Triassic		250
	Paleozoic	Permian		
		Carboniferous: Pennsylvanian		
		Carboniferous: Mississippian		
		Devonian		
		Silurian		
		Ordovician		
		Cambrian		540
Precambrian	Proterozoic			2500
	Archean			3800
	Hadean			4600

Nanaimo Geotour 2015

Welcome to the Nanaimo Geotour!

Learning about our Earth, geological processes and features, and the relevance of it all to our lives is really best addressed outside of a classroom. Our entire province is *the* laboratory for geoscape studies. The landscape and rocks of the Nanaimo area record many natural Earth processes and reveal a large part of the geologic history of Vancouver Island – a unique part of the Canadian Cordilleran.

This professional development field trip for teachers stops at key features that are part of the geological story - demonstrating surface processes, recording rock – forming processes, revealing the tectonic history, and evidencing glaciation. The important interplay of these phenomena and later human activity is highlighted along the way. It is designed to build your understanding of Earth Science to support your teaching.

Acknowledgments

We would like to thank our partner and field trip leader, Dr. Jerome Lesemann. Dr. Lesemann is a geologist and Professor in the Earth Science Department at Vancouver Island University. His specialization is Quaternary geology, sedimentology and stratigraphy. He has worked for the Geological Survey of Canada and various universities. His research includes reconstructions of ice sheet dynamics and glacial processes and applications of these topics to aquifer characterization and mineral exploration in the northern Canada.

Dr. Lesemann has modified the *Nanaimo Geotour 2015* guide from an original document written by Steven Earle (V.I.U.), with contributions from Tim Stokes (V.I.U.) and Malaika Ulmi (Geological Survey of Canada) (all photos by Steve Earle).

We are grateful to Dr. Lesemann who has kindly shared his time and expertise to help build your interest in and understanding of the natural history of the Nanaimo area, and to inspire your teaching.

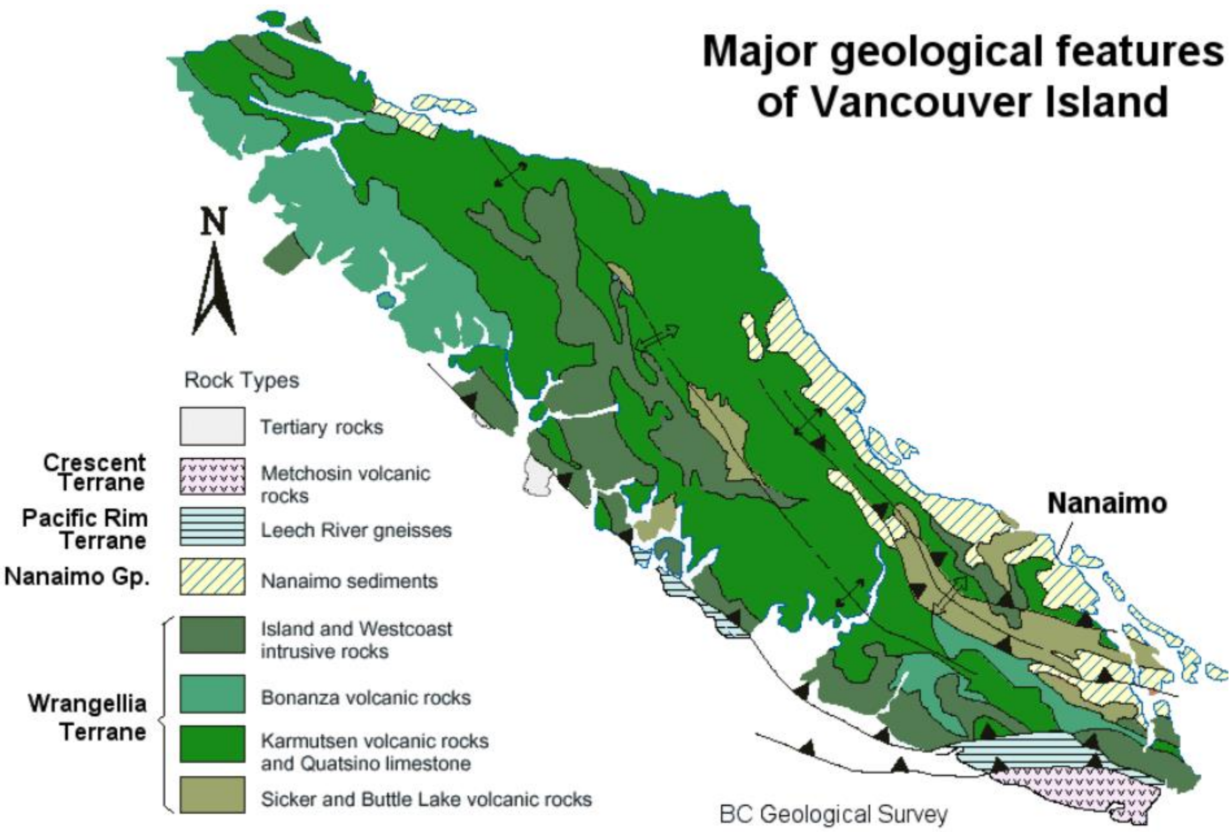
Sheila R. Stenzel, Director
MineralsEd
October 2015

Introduction

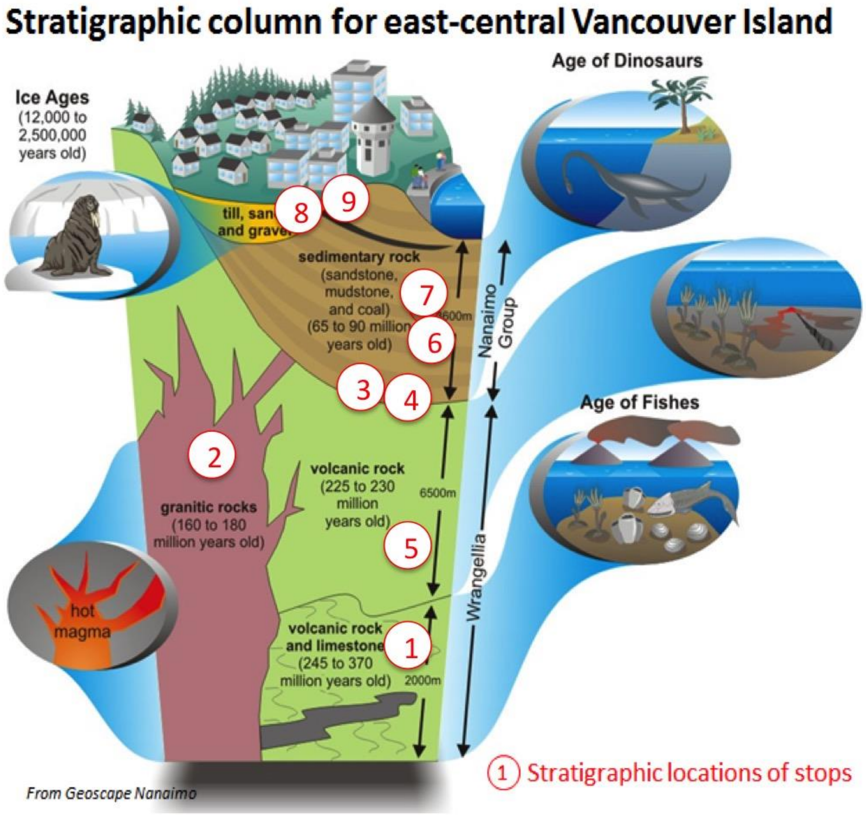
Vancouver Island is on the leading edge of the Cascadia Subduction Zone, and is the western front of a series of terranes that have accreted against the North American continent. The regional tectonic environment results in interesting and varied geology and topography, and also natural hazards that include earthquakes, volcanoes, tsunamis and landslides.

During this tour we'll be looking at rocks that range in age from around 350 million years (Ma) old to about 70 Ma, and at unconsolidated glacial materials that are around 25 thousand years (ka) old. The older rocks (Stops 4, 5, 6 and 8) are part of the Wrangellia Terrane, which originated in the Pacific Ocean and was accreted onto the edge of North America about 100 Ma ago. The younger rocks (Stops 1, 2, 6 and 8) were deposited after that collision, along the boundary between Wrangellia and North America. The unconsolidated deposits (Stop 3) were deposited during the last glaciation.

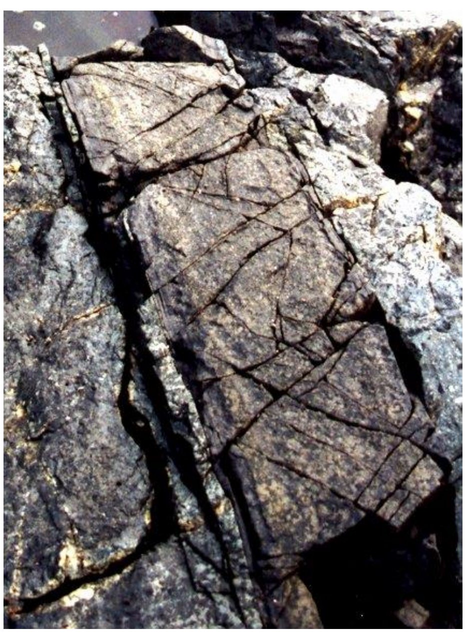
The nine stops of this tour are in order of convenience, considering where we are starting this field trip and the tides. They are not in order of geological age. There is location map on the back page.



S. Earle after the BC Geological Survey

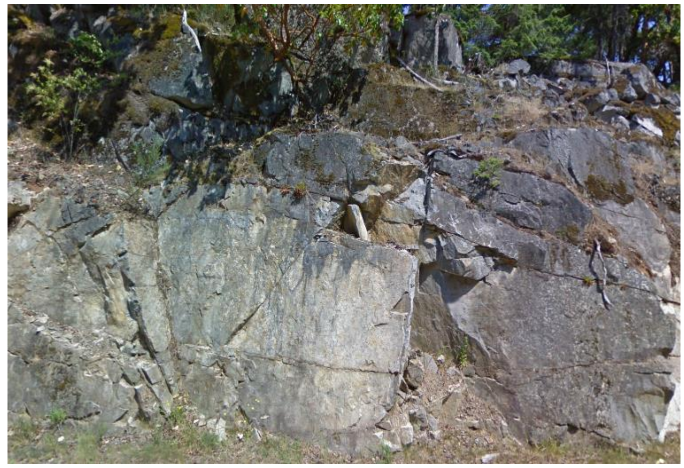


Stop 1: Sea-floor volcanic rock at Neck Point (Triassic, ~ 210 Ma)



Some of the best examples of **igneous rocks** that compose Vancouver Island are exposed at Neck Point and along the eastern coast of the Straight of Georgia between Nanaimo and Nanoose. On the rocky coast and wave-cut platforms at Neck Point, we can examine some good examples of **basaltic volcanic rocks** formed on the sea floor. As the hot mafic magma flowed out into the cold seawater, its outer surface cooled very quickly forming a “skin” that contained the liquid magma inside. Blobs of this material accumulated around the volcanic vent on the sea floor. These are known as **pillows**, and the rock is a **pillow-basalt**. Pillows are easily visible on multiple outcrops; they sometimes have slightly finer textures around the edge than in the middle because the edges cooled faster.

Stop 2: Granitic rock at Fairwinds in Nanoose (Jurassic, ~ 180 Ma)



Long before Wrangellia reached the edge of North America it was largely made up of sea-floor volcanic rocks and was mostly at or entirely below sea level. Around 180 Ma ago another oceanic plate was pushed (subducted) beneath Wrangellia. This led to the production of magma and to the formation of Jurassic-aged volcanic rocks that we don't see in this part of Vancouver Island. The magma chambers that fed the Jurassic volcanoes eventually cooled to become **granitic bodies** like those exposed in the Fairwinds area.

The plate interactions and magmatic activity during the Jurassic contributed to the uplift of Wrangellia, and by the end of this period much more of it was exposed above sea level. Several dark (**mafic**) **dykes** cross-cut these granitic rocks. The age of these dykes isn't known, but they are obviously younger than the granite.

Stop 3: Sedimentary and meta-sedimentary rocks of the Nanoose Complex and basal Nanaimo Groups rocks at Cottam Point (Cretaceous, ~ 90 Ma)

Some of the oldest rocks on Vancouver Island form part of the Nanoose Complex —a block of rock uplifted from the base of Wrangellia. These rocks are comparable to other old rocks of the Sicker Group in the central part of Vancouver Island. At Cottam Point some of **sedimentary** and **meta-sedimentary rocks** of the Nanoose Complex are exposed on the rocky shoreline. As well, some of the oldest rocks of the Nanaimo Group overly the Nanoose Complex. The relationship between these rocks indicates a major time gap in the stratigraphic sequence of rocks on Vancouver Island. (The time gap, and the surface marked by it, are known as an **unconformity**.) It also marks a significant change in the depositional environments and processes responsible for creating these rocks.

Stop 4: Karmutsen Formation volcanic rock and basal Nanaimo Group sediments at Stephenson Point (Cretaceous, ~ 90 Ma) (2 stops close by – second one optional depending on tides).

At Stephenson Point we can see examples of the oldest rocks of the Nanaimo Group, and if the tide permits, we'll also see some of the underlying pillow basalts of the Triassic Karmutsen Formation. The Karmutsen rock here is quite similar to those at Neck Point. There are some excellent pillows exposed in some of the large boulders on the shore, and in outcrops.

The **sedimentary rocks** here, which were deposited along an ancient shoreline, are part of the oldest formation of the Nanaimo Group (Comox Formation). These rocks are equivalent (in appearance and age) to those seen at Cottam Point. However, here, they rest directly on the Karmutsen Formation pillow basalts. The Nanaimo Group layer is **conglomerate**, ranging from one to several metres in thickness, and it is mostly comprised of pebble- to cobble-sized clasts of Karmutsen basalt. These are well rounded, and, in places, quite well sorted. The conglomerate is overlain by a bed of cream-coloured **limestone** that is up to a few metres thick, and is almost entirely composed of 1 to 3 mm sized fragments of coralline algae. This material likely accumulated in a beach of shallow marine shelf environment. The limestone is succeeded by a dark green **calcareous sandstone** that is rich in marine fossils. Look for examples of oysters, trigonid bivalves, inoceramid clams and crinoids.


Conglomerate and coralline-algae limestone


Conglomerate with a crinoid stem

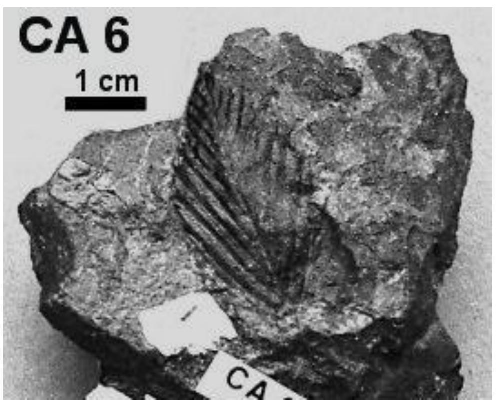
Stop 5: Malaspina Cut (time permitting)

The Malaspina Cut exposes some of the Comox Formation of the Nanaimo Group, resting on Karmutsen Basalt. The site is an important one for the study of the evolution of western North America. The method of paleomagnetism can be used to determine the timing and the latitude where the Nanaimo Group sediments were deposited. These **paleomagnetic** results (and many others) suggest that deposition of the Nanaimo Group occurred at much lower latitudes than where the rocks are found today. The most significant implication of these findings is that *the basin of the Nanaimo Group has been shifted 1000s of km to its present position*. This shifting is part of large-scale tectonic movements that have affected western North America.

Stop 6 Palm Frond at Vancouver Island University (Cretaceous, ~ 70 Ma)

Most of the Nanaimo area, and much of eastern Vancouver Island, is underlain by sedimentary rocks of the Cretaceous Nanaimo Group. Most of the rocks are either mudstone, sandstone or conglomerate, and they were deposited in rivers, deltas and a variety of different marine environments on Wrangellia and between Wrangellia and the mainland between 95 and 65 Ma. Significant thicknesses (several thousand metres) of these sediments accumulated and eventually lithified into the rocks we see today.

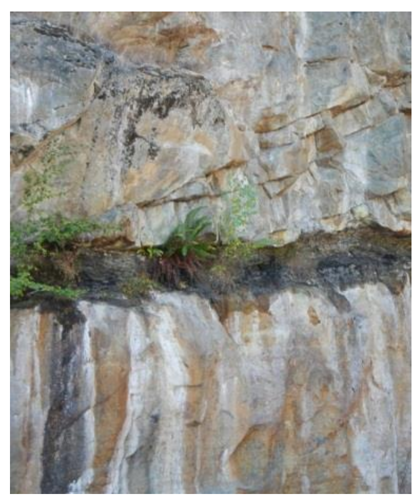
The Earth's climate was warmer throughout the Cretaceous than it is now, and fossils from the Nanaimo Group reflect this difference. The giant palm (*Phoenicites imperials*) grew alongside over 40 different broadleaf trees and shrubs, plus conifers and ferns. Their leaves and branches accumulated in mud and fine sand in a quiet backwater of a river environment at what is now the Cranberry Arms site in Cedar. An analysis of the morphology and margin type (toothed vs smooth) of dicot leaves from this site indicates a humid climate with a mean annual temperature of around 20° C, about 10° warmer than today's climate on Vancouver Island.



Dicot leaves from the Cranberry Arms site where the giant palm frond was found

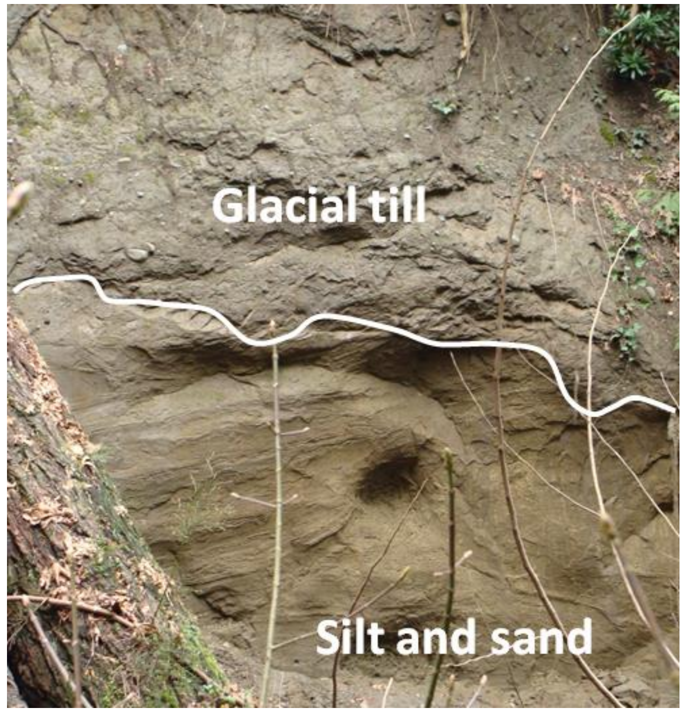
Stop 7 Nanaimo Group rocks and coal at Cavan Street parkade (Cretaceous, ~ 75 Ma)

Nanaimo was founded in the mid-1800s as a coal mining town. The **coal seam** exposed in this parking lot dips down to the east and extends beneath the harbour. It was mined at depths of up to several hundred metres below sea level. The conglomerate below the coal and the sandstone above it were deposited in a river environment, and the coal itself in a swampy area beside the river. Coal mining continued in the Nanaimo area until about 1950, but was discontinued because of depletion of the reserves and because of labour issues, partly due to dangerous working conditions. Coal mining is still ongoing in the Campbell River area at the underground Quinsam Mine.



Conglomerate (bottom), coal, and sandstone (top)

Stop 8 Glacial sediments at Beach Estates Park (Pleistocene, ~ 25 ka)

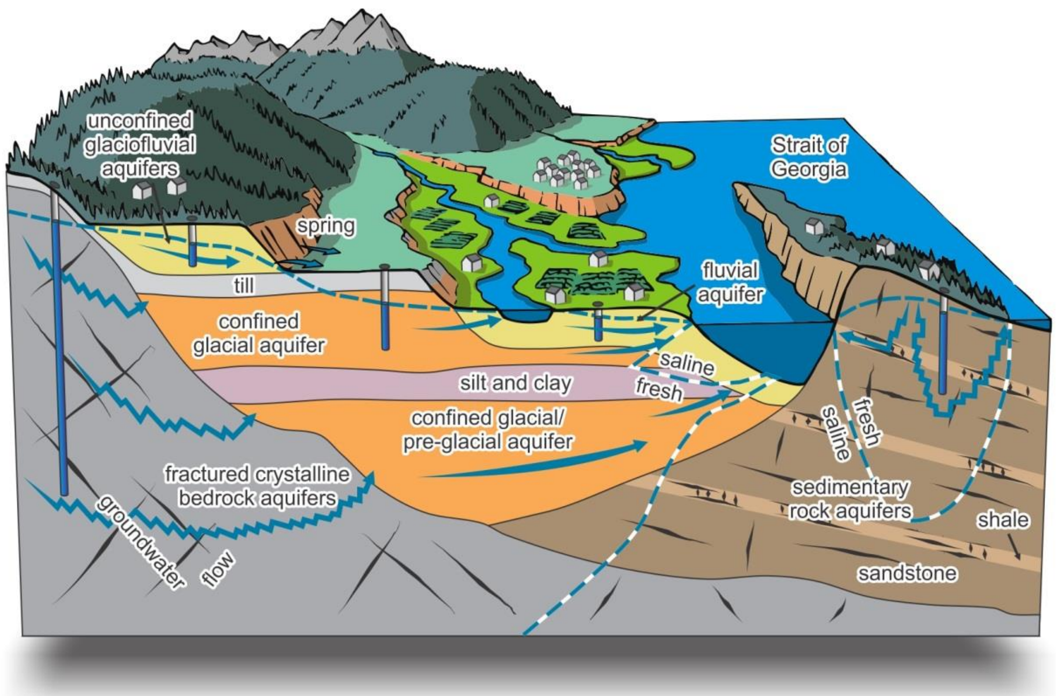


Along with the rest of Vancouver Island and the adjacent mainland, the Nanaimo area was repeatedly glaciated over the past million years or more. As the ice of the most recent glaciation (the Fraser Glaciation) advanced south along Georgia Strait layers of gravel, sand, silt and clay were deposited in front of it from melt-water outflows. Elsewhere sediments similar to these are known as the Quadra Sand, and it is likely that the silt and sand exposed at Beach Estates Park is also part of that unit. The ice then pushed over top of these materials, depositing unsorted glacial till.

Over the 12,000 years since deglaciation the stream at Beach Estates Park has eroded a steep gully into these soft glacial sediments. In many places the gully walls are failing, and some of the properties and buildings at the top are at risk.

Stop 9 Nanaimo River gravel pits and aquifers in the Nanaimo Lowlands

Groundwater in the Nanaimo Lowlands is increasingly important in supporting agriculture, population growth and urban development. It also plays an important role for fisheries and aquatic habitats such as wetlands, lakes and streams. A thorough understanding of the groundwater resource is essential to ensure a sustainable balance between natural and human activities. Large quantities of groundwater are stored in sand and gravel deposited during the last ice age. Understanding the depositional environments of these sediments is important for proper management of groundwater resources and for local groundwater studies that include surface water and groundwater interactions, salt water intrusion, and aquifer recharge.



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October, 2015

References

Information on the geology of the Nanaimo area is available at the **Geoscape Nanaimo** website: [*http://web.viu.ca/geoscape/*](http://web.viu.ca/geoscape/)

The geology of the Nanoose area is described in: *Yorath, C; Sutherland Brown, A; Massey, N, 1999, LITHOPROBE, southern Vancouver Island, British Columbia. Geological Survey of Canada, Bulletin 498, 145 p.*

A good summary of the geology of southern Vancouver Island is provided in: *Yorath, C., 2005, Geology of Southern Vancouver Island Revised Edition, Harbour Publishing, Victoria.*

Nanaimo Group rocks are described in: *Mustard, P., 1994, The Upper Cretaceous Nanaimo Group, Georgia Basin: In Geology and Geological Hazards of the Vancouver Region, SW British Columbia, J. Monger (ed.), Geological Survey of Canada, Bulletin 481, p. 27-95.*

Information on the climate implications of leaf fossils from the Cranberry Arms is given in: *Pearson, J. and Hebda, R., 2006, Paleoclimate of the Late Cretaceous Cranberry Arms flora of Vancouver Island : evidence for latitudinal displacement , in Paleogeography of the North American Cordillera: evidence for and against large-scale displacements, Haggart, J., Enkin, R. and Monger, J., (eds.) Geological Association of Canada, Special Paper 46.*

2015 Nanaimo Area Geotour - Planned Stops