Saanich Inlet, southern Vancouver Island

Geology of an Aspiring Global Geopark

CANADIAN GEOPARKS NETWORK
MENTORING & GUIDING GEOPARKS

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Saanich Inlet: An Aspiring Global Geopark

In anticipation of a proposal to the UNESCO Global Geopark Network, the Canadian National Committee for Global Geoparks has accepted Saanich Inlet and its watershed on southern Vancouver Island as an Aspiring Geopark. This Geopark initiative, led by the Saanich Inlet Protection Society, is seeking the support of local residents, First Nation communities, businesses, marine groups and scientists from government, universities, and industry. Geoparks are community-driven enterprises that reflect the desires and values of the people living in them. This Geopark will protect the natural resources and cultural heritage of Saanich Inlet while encouraging environmentally sound economic development. Geoheritage recognizes the continuum between the geological record and cultural values.

Like the more than 75 Geoparks worldwide, Saanich Inlet has an internationally significant geologic record that has been intensively researched on land and in the sea. It also has a long human history, enduring cultural traditions, vibrant communities, and environmentally respectful commercial activities.

The Saanich Inlet region offers exceptional opportunities for public education. It includes the City of Victoria, a major global tourist destination. Although small, the region is rich in venues for experiential learning about oceanography, tectonics, paleogeographic reconstructions, the most recent ice age, and modern coastal and deep-water processes. Easy access to the inlet's geology is provided by extensive hiking trails, bike paths, road cuts, public beaches, and docking facilities, many of which are in provincial and municipal parks. Visitors will gain an increased appreciation of our natural heritage and a better grasp of the interactive feedbacks between land, air, water, organisms, and human activity. They will also gain an improved understanding of society's attempts to mitigate, and become more resilient to, problems like climate change, environmental contamination, and geologic hazards including earthquakes, tsunamis, volcanic eruptions, floods, landslides, and wildfires.

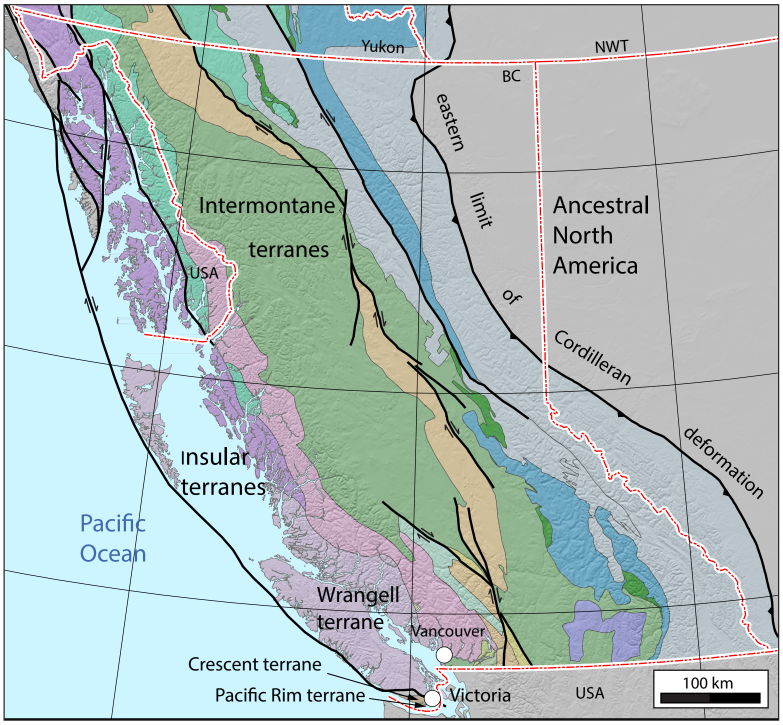
Saanich Inlet is a glacially carved fiord, more than 25 km long and up to 235 m deep. It forms part of the Salish Sea, the name for the area of coastal waters of southern British Columbia and northern Washington State that refers to the language of the First Nations groups that originally occupied the region.

Our understanding of the Saanich Inlet region has come from more than a hundred years of scientific investigations and generations of First Nations traditional knowledge. Cores of sediment collected from the drill ship *Resolution* during a 1996 expedition of the Joint Oceanographic Institutions for Deep Earth Sampling (JOIDES) Ocean Drilling Program, record the history of the inlet during and following retreat of ice from the most recent advance of the Cordilleran Ice Sheet (Fraser glaciation). Along with providing an archive of changing climates in the last 13,000 years, these cores reveal a history punctuated by catastrophic floods, slope failures, earthquakes, and volcanic activity. For the last 7,000 years, water circulation has been restricted, owing to a shallow sill (about 70 m deep) at the mouth of the inlet. As a consequence, Saanich Inlet is a rare modern example of an anoxic marine basin. Deep waters lack adequate oxygen for sediment-churning, bottom-dwelling organisms to destroy delicately laminated sediments. This enables high-resolution reconstructions of past climates, ocean chemistry, relative sea-level changes, environments, biota, and seismicity, including an estimated recurrence interval for major seismic events of 200 to 500 years.

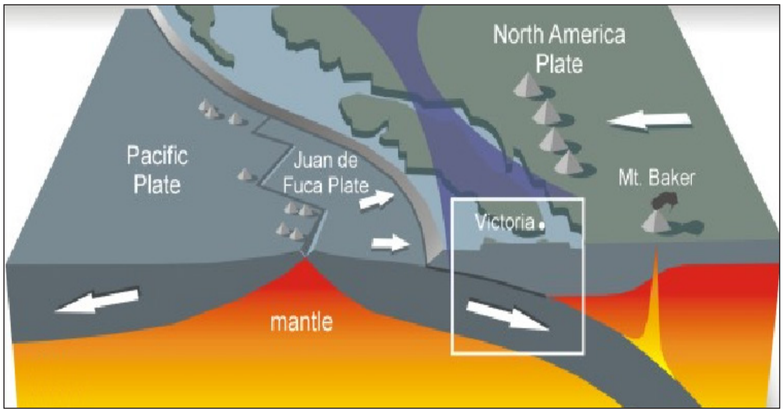
The inlet continues to be investigated, notably at the VENUS observatory (Victoria Experimental Network Under the Sea) of Ocean Networks Canada at the School of Earth and Ocean Sciences, University of Victoria. VENUS has deployed cabled ocean sensors throughout Saanich Inlet that stream real-time data around the world. Bedrock, surficial geology, and seismic studies continue at the British Columbia Geological Survey, and the Pacific Geoscience Centre of the Geological Survey of Canada.

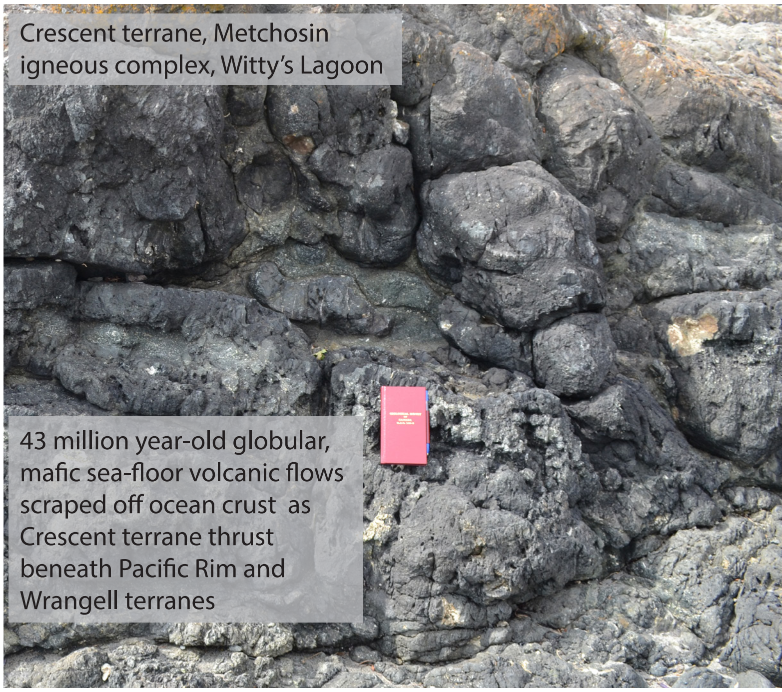
Cordilleran tectonics, ancient and modern: Visitors to the Saanich Inlet Geopark region can transect the rocks and structures that record past and present tectonic plate interactions

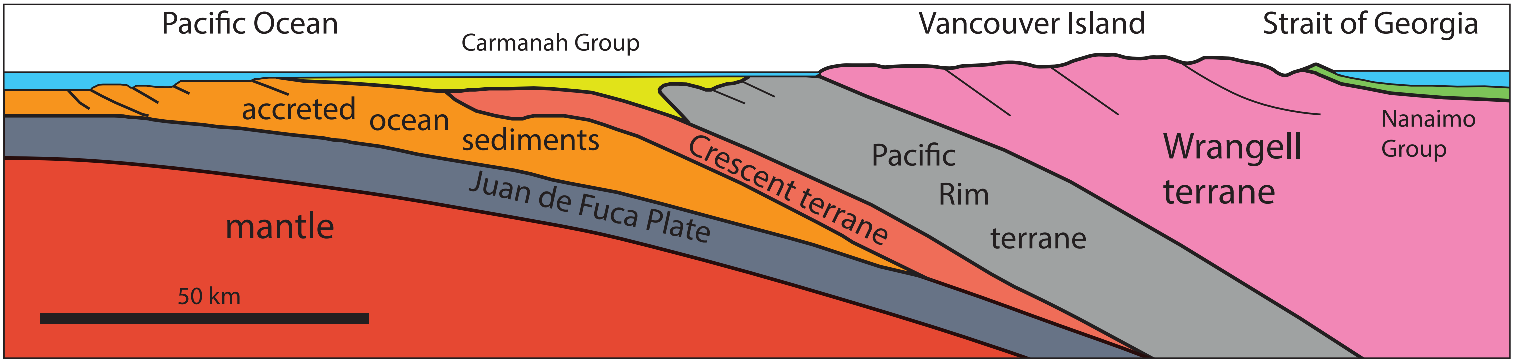
Vancouver Island is on the western flank of the Canadian Cordillera, a tectonic collage of far-travelled, in some cases several 1000 km, crustal slices (terranes) that welded to the margin of Ancestral North America in the last 180 million years.



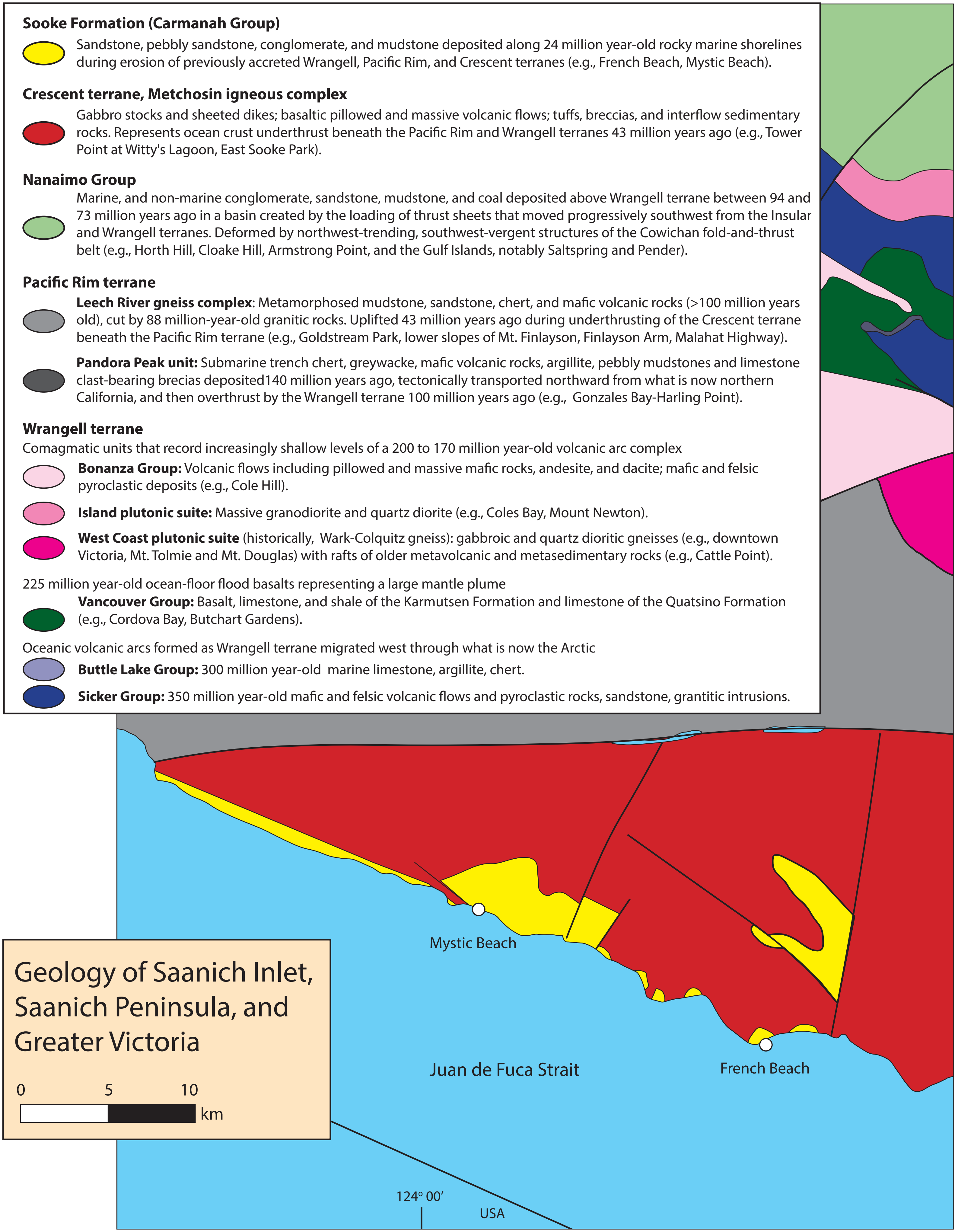
Today, oceanic crust of the Juan de Fuca plate slides eastward beneath previously accreted terranes on Vancouver Island along the Cascadia subduction zone, generating earthquakes and volcanoes.

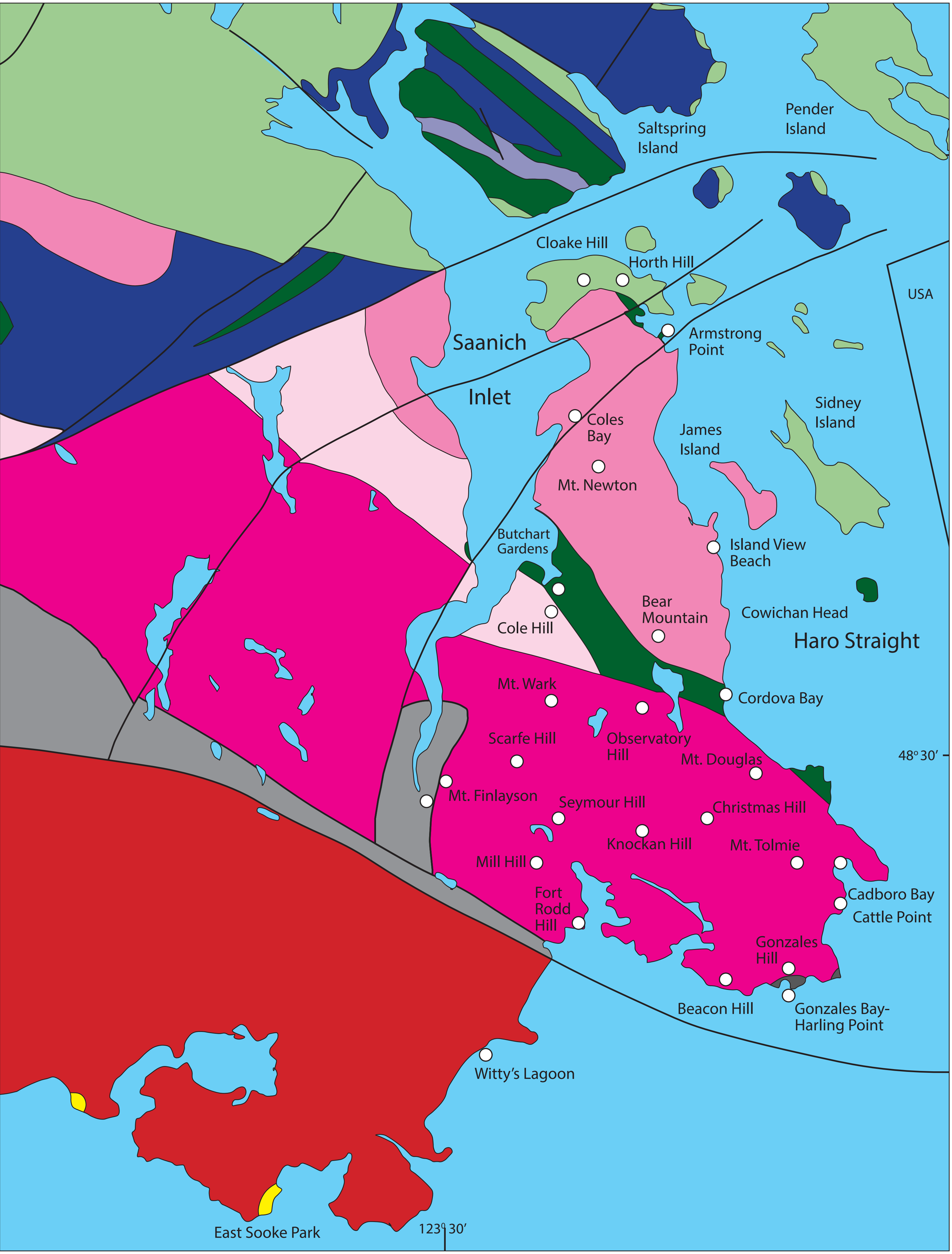






Wrangell, Pacific Rim, and Crescent terranes stacked up on Vancouver Island. Eastward subduction of ocean crust beneath Vancouver Island continues today. The many bedrock exposures in the Saanich Inlet region would enable Geopark visitors to bear witness to the past continental collisions that constructed the western Canadian Cordillera.

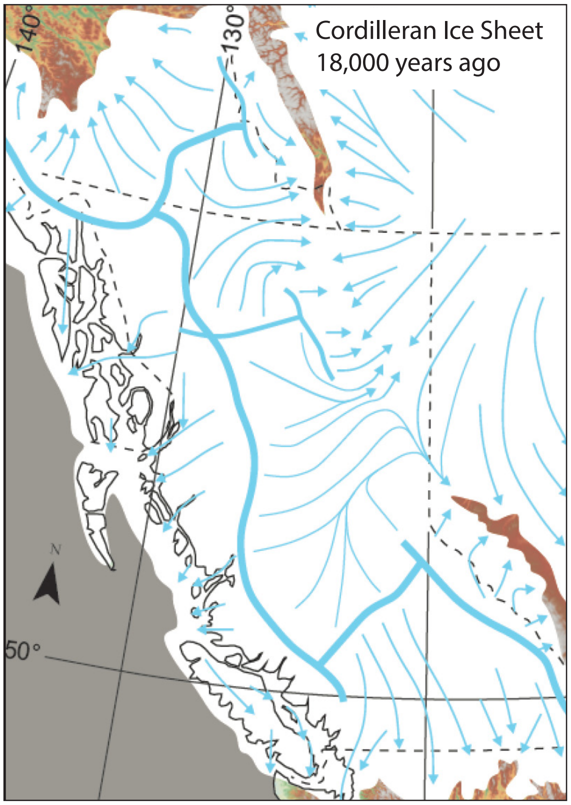

Sooke Formation (Carmanah Group)
Sandstone, pebbly sandstone, conglomerate, and mudstone deposited along 24 million year-old rocky marine shorelines during erosion of previously accreted Wrangell, Pacific Rim, and Crescent terranes (e.g., French Beach, Mystic Beach).
Crescent terrane, Metchosin igneous complex
Gabbro stocks and sheeted dikes; basaltic pillowed and massive volcanic flows; tuffs, breccias, and interflow sedimentary rocks. Represents ocean crust underthrust beneath the Pacific Rim and Wrangell terranes 43 million years ago (e.g., Tower Point at Witty's Lagoon, East Sooke Park).
Nanaimo Group
Marine, and non-marine conglomerate, sandstone, mudstone, and coal deposited above Wrangell terrane between 94 and 73 million years ago in a basin created by the loading of thrust sheets that moved progressively southwest from the Insular and Wrangell terranes. Deformed by northwest-trending, southwest-vergent structures of the Cowichan fold-and-thrust belt (e.g., Horth Hill, Cloake Hill, Armstrong Point, and the Gulf Islands, notably Saltspring and Pender).
Pacific Rim terrane
Leech River gneiss complex: Metamorphosed mudstone, sandstone, chert, and mafic volcanic rocks (>100 million years old), cut by 88 million-year-old granitic rocks. Uplifted 43 million years ago during underthrusting of the Crescent terrane beneath the Pacific Rim terrane (e.g., Goldstream Park, lower slopes of Mt. Finlayson, Finlayson Arm, Malahat Highway).
Pandora Peak unit: Submarine trench chert, greywacke, mafic volcanic rocks, argillite, pebbly mudstones and limestone clast-bearing brecias deposited140 million years ago, tectonically transported northward from what is now northern California, and then overthrust by the Wrangell terrane 100 million years ago (e.g., Gonzales Bay-Harling Point).
Wrangell terrane
Comagmatic units that record increasingly shallow levels of a 200 to 170 million year-old volcanic arc complex
Bonanza Group: Volcanic flows including pillowed and massive mafic rocks, andesite, and dacite; mafic and felsic pyroclastic deposits (e.g., Cole Hill).
Island plutonic suite: Massive granodiorite and quartz diorite (e.g., Coles Bay, Mount Newton).
West Coast plutonic suite (historically, Wark-Colquitz gneiss): gabbroic and quartz dioritic gneisses (e.g., downtown Victoria, Mt. Tolmie and Mt. Douglas) with rafts of older metavolcanic and metasedimentary rocks (e.g., Cattle Point).
225 million year-old ocean-floor flood basalts representing a large mantle plume
Vancouver Group: Basalt, limestone, and shale of the Karmutsen Formation and limestone of the Quatsino Formation (e.g., Cordova Bay, Butchart Gardens).
Oceanic volcanic arcs formed as Wrangell terrane migrated west through what is now the Arctic
Buttle Lake Group: 300 million year-old marine limestone, argillite, chert.
Sicker Group: 350 million year-old mafic and felsic volcanic flows and pyroclastic rocks, sandstone, grantitic intrusions.
Mystic Beach
French Beach
Juan de Fuca Strait
Geology of Saanich Inlet, Saanich Peninsula, and Greater Victoria
0
5
10
km
124° 00′
USA

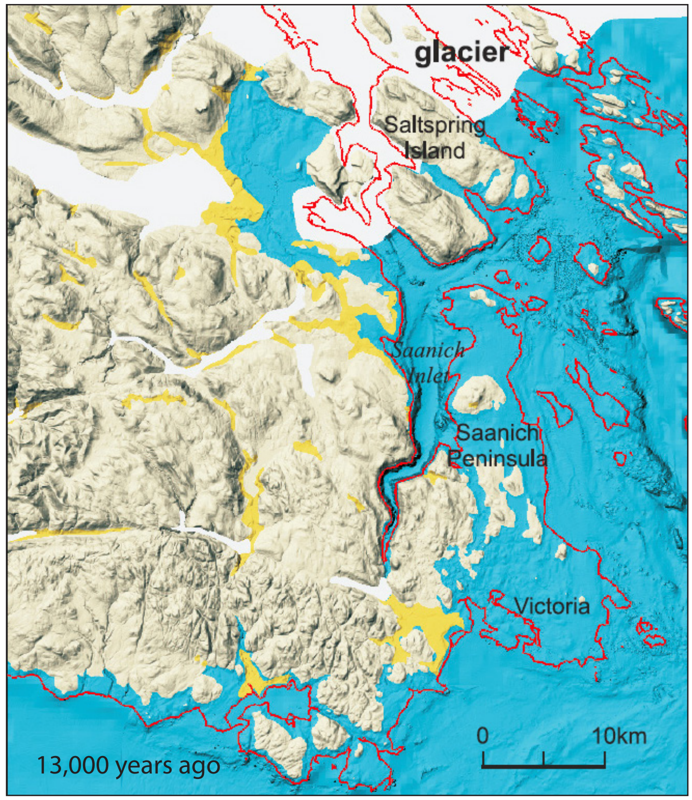


Saltspring Island
Pender Island
Cloake Hill
Horth Hill
USA
Saanich
Inlet
Armstrong Point
Sidney Island
Coles Bay
James Island
Mt. Newton
Butchart Gardens
Island View Beach
Bear Mountain
Cowichan Head
Cole Hill
Haro Straight
Mt. Wark
Cordova Bay
Scarfe Hill
Observatory Hill
Mt. Douglas
48° 30′
Mt. Finlayson
Seymour Hill
Christmas Hill
Knockan Hill
Mt. Tolmie
Mill Hill
Fort Rodd Hill
Cadboro Bay
Cattle Point
Gonzales Hill
Beacon Hill
Gonzales Bay-Harling Point
Witty's Lagoon
East Sooke Park
123° 30′

The recent glacial past: Abundant glacigenic deposits and erosional features testify to the Saanich Inlet region's relatively young (less than 25,000 years) icy past

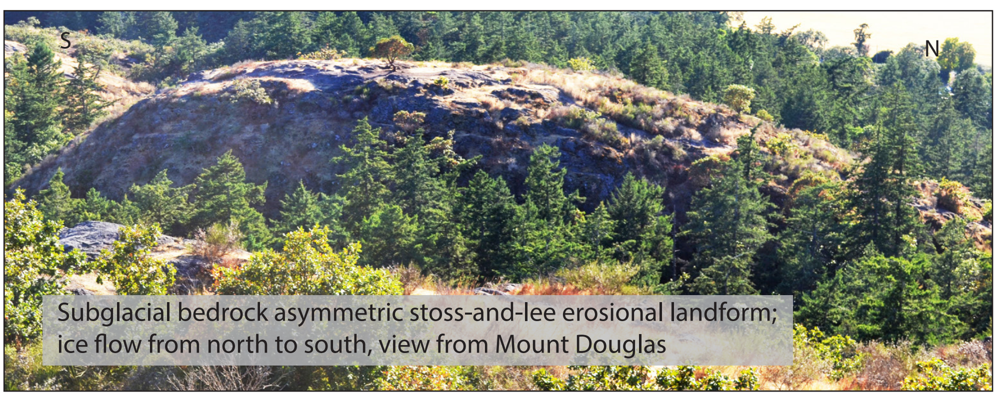
As with other parts of the globe, the Canadian Cordillera saw multiple glacial and nonglacial episodes in the last 2.6 million years. Although evidence of earlier glaciations is locally preserved in the Saanich Inlet region, most of the glacigenic deposits and erosional features formed during the Fraser glaciation, the most recent advance of the Cordilleran Ice Sheet.





About 25,000 years ago, glaciers flowed from peaks along the spine of Vancouver Island and moved across Saanich Inlet. By 18,000 years ago, Saanich Inlet and Greater Victoria were covered by an ice sheet up to 1.5 kilometres thick. At the glacial maximum, the ice sheet included a lobe flowing south along Puget Sound and west along the Juan de Fuca Strait. Deglaciation was relatively rapid, and the Saanich Inlet area became ice free 13,000 years ago. Deglaciation created a paleogeography of ice-free uplands separating ice-filled valleys, with meltwaters depositing glaciofluvial, glaciolacustrine, and glaciomarine sediments. Relative sea level then fell as the land rebounded from being buried beneath the load of ice.

Multi-scale subglacial bedrock erosional features, including stoss-and-lee forms, streamlined forms, grooves, striae, and polished surfaces are common, particularly on the many hills in the region. Unusual subglacial erosional features, formed by the combined action of ice, ice-embedded debris, and water are locally developed (e.g., Harling Point) as are combined erosional and depositional crag-and-tail landforms (e.g., Mount Douglas, Mount Newton, Mount Tolmie).



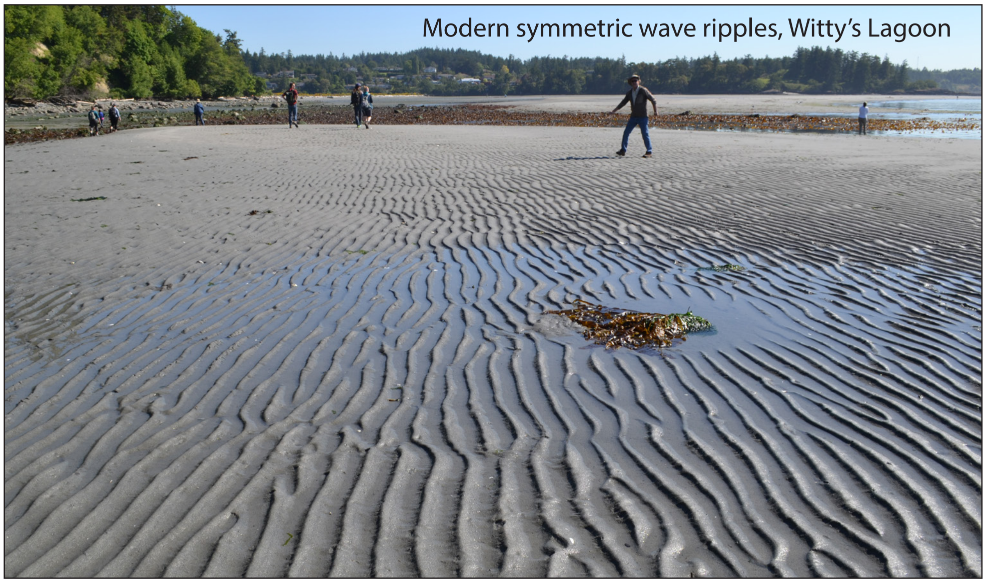
Subglacial bedrock asymmetric stoss-and-lee erosional landform; ice flow from north to south, view from Mount Douglas

Asymmetric drumlin ridge indicating southeast ice flow along the Strait of Georgia. James Island, view from Island View Beach

Deposits related to the Fraser glaciation (Late Wisconsin) are widespread, but older deposits (pre-Wisconsin and Early Wisconsin) are preserved locally. Cliff sections such as at Cowichan Head, Island View Beach, and Parry Bay (Witty's Lagoon) expose >65,000 to 10,000 year-old glacial and interglacial deposits. Extending from Sidney Island to central Saanich Peninsula is a field of southeast-trending, till-mantled drumlins 1-3 km long and up to 75 m high.

Modern beaches: Great places to observe processes of erosion, transport, and deposition and learn how ancient sedimentary deposits form

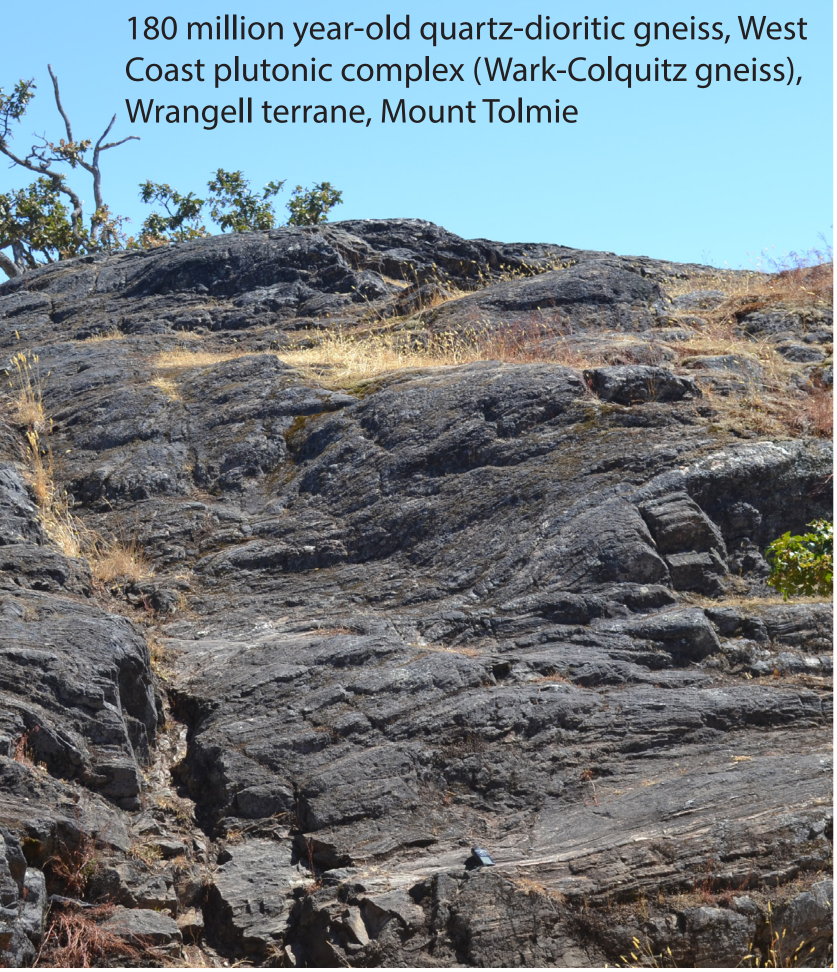
The many beaches along the coastlines of Saanich Inlet and Saanich Peninsula provide excellent opportunities to observe ongoing erosional, mass wasting, fluvial, eolian, tidal, wave, and biogenic processes. They are also great places to observe the sedimentary textures, structures, and geometric relationships these processes generate, which can then be used to identify the sedimentary environments of ancient rocks.



In contrast to asymmetric ripples formed by unidirectional flow, symmetric ripples form by the oscillatory water motion of waves and help to differentiate ancient beach and fluvial deposits. They also help to quantify water depths and establish shoreline trends in ancient sequences.

The onshore and offshore migration of sand and gravel strips creates sheet-like interbeds of sandstone and conglomerate in ancient sequences, such as displayed at cliff exposures of 24 million-year-old Sooke Formation (Carmanah Group) rocks at Mystic Beach.

Micro-delta forming as sand-laden water in the stream draining the tidal pool on the right enters standing water in the pool on the left. Studying small-scale processes, and the products they generate, helps to better understand how large-scale river and delta deposits form and how they can be recognized in the rock record.



180 million year-old quartz-dioritic gneiss, West Coast plutonic complex (Wark-Colquitz gneiss), Wrangell terrane, Mount Tolmie

24 million year-old fossil-rich beach sandstones, Sooke Formation (Carmanah Group), French Beach

Modern mesotidal storm-dominated tidal sand flat, Witty's Lagoon

British Columbia Geological Survey Information Circular 2018-3

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Canada 1842 Geological Survey - Commission Géologique

Ocean Networks Canada

University of Victoria Earth and Ocean Sciences

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