Natural Resources Canada / Ressources naturelles Canada — Fisheries and Oceans Canada / Pêches et Océans Canada
GEOLOGICAL SURVEY OF CANADA — COMMISSION GÉOLOGIQUE DU CANADA

## DESCRIPTIVE NOTES

### INTRODUCTION

### METHODS

### SURFICIAL GEOLOGY

#### Upper Cretaceous Nanaimo Group

#### Glacial sediments

#### Postglacial sediments

### ACKNOWLEDGEMENTS

### REFERENCES

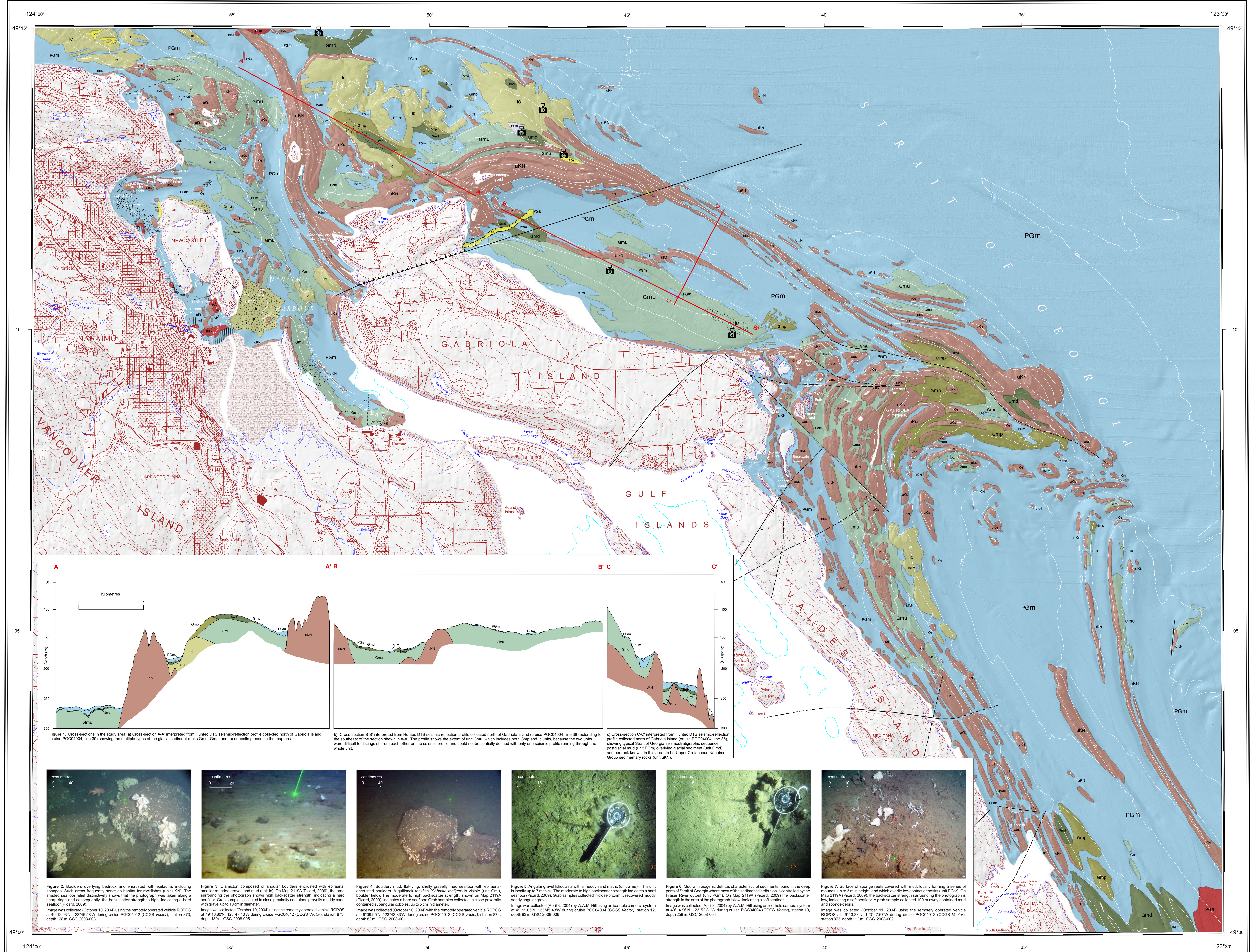

**Figure 1.** Cross-sections in the study area. **a)** Cross-section A-A' interpreted from Huntec DTS seismic-reflection profile collected north of Gabriola Island (cruise PGC04004, line 39) showing the multiple types of the glacial sediment (units Gmd, Gmp, and Ic) deposits present in the map area.

**b)** Cross-section B-B' interpreted from Huntec DTS seismic-reflection profile collected north of Gabriola Island (cruise PGC04004, line 38) extending to the southeast of the section shown in A-A'. The profile shows the extent of unit Gmu, which includes both Gmp and Ic units, because the two units were difficult to distinguish from each other on the seismic profile and could not be spatially defined with only one seismic profile running through the whole unit.

**c)** Cross-section C-C' interpreted from Huntec DTS seismic-reflection profile collected north of Gabriola Island (cruise PGC04004, line 35), showing typical Strait of Georgia seismostratigraphic sequence: postglacial mud (unit PGm) overlying glacial sediment (unit Gmd) and bedrock known, in this area, to be Upper Cretaceous Nanaimo Group sedimentary rocks (unit uKN).

**Figure 2.** Boulders overlying bedrock and encrusted with epifauna, including sponges. Such areas frequently serve as habitat for rockfishes (unit uKN). The shaded seafloor relief distinctively shows that the photograph was taken along a sharp ridge and consequently, the backscatter strength is high, indicating a hard seafloor (Picard, 2009).

Image was collected (October 10, 2004) using the remotely operated vehicle ROPOS at 49°12.93'N, 123°46.58'W during cruise PGC04012 (CCGS *Vector*), station 873, depth 128 m. GSC 2008-003

**Figure 3.** Diamicton composed of angular boulders encrusted with epifauna, smaller rounded gravel, and mud (unit Ic). On Map 2119A (Picard, 2009), the area surrounding the photograph shows high backscatter strength, indicating a hard seafloor. Grab samples collected in close proximity contained gravelly muddy sand with gravel up to 10 cm in diameter.

Image was collected (October 10, 2004) using the remotely operated vehicle ROPOS at 49°13.80'N, 123°47.40'W during cruise PGC04012 (CCGS *Vector*), station 873, depth 180 m. GSC 2008-005

**Figure 4.** Bouldery mud; flat-lying, shelly gravelly mud seafloor with epifauna-encrusted boulders. A quillback rockfish (*Sebaste maliger*) is visible (unit Gmu, boulder field). The moderate to high backscatter strength, shown on Map 2119A (Picard, 2009), indicates a hard seafloor. Grab samples collected in close proximity contained subangular cobbles, up to 5 cm in diameter.

Image was collected (October 10, 2004) with the remotely operated vehicle ROPOS at 49°09.95'N, 123°42.33'W during cruise PGC04012 (CCGS *Vector)*, station 874, depth 82 m. GSC 2008-001

**Figure 5.** Angular gravel lithoclasts with a muddy sand matrix (unit Gmu). This unit is locally up to 7 m thick. The moderate to high backscatter strength indicates a hard seafloor (Picard, 2009). Grab samples collected in close proximity recovered muddy sandy angular gravel.

Image was collected (April 3, 2004) by W.A.M. Hill using an ice-hole camera system at 49°11.05'N, 123°45.43'W during cruise PGC04004 (CCGS *Vector),* station 12, depth 93 m. GSC 2008-006

**Figure 6.** Mud with biogenic detritus characteristic of sediments found in the deep parts of Strait of Georgia where most of the sediment distribution is controlled by the Fraser River output (unit PGm). On Map 2119A (Picard, 2009) the backscatter strength in the area of the photograph is low, indicating a soft seafloor.

Image was collected (April 3, 2004) by W.A.M. Hill using an ice-hole camera system at 49°14.96'N, 123°52.81'W during cruise PGC04004 (CCGS *Vector*), station 19, depth 258 m. GSC 2008-004

**Figure 7.** Surface of sponge reefs covered with mud, locally forming a series of mounds, up to 3 m in height, and which overlie ice-contact deposits (unit PGsr). On Map 2119A (Picard, 2009), the backscatter strength surrounding the photograph is low, indicating a soft seafloor. A grab sample collected 100 m away contained mud and sponge debris.

Image was collected (October 11, 2004) using the remotely operated vehicle ROPOS at 49°13.33'N, 123°47.67'W during cruise PGC04012 (CCGS *Vector*), station 873, depth 112 m. GSC 2008-002

## LEGEND

### QUATERNARY

#### POSTGLACIAL SEDIMENTS

*Geological processes delivering significant sediments to the study area include a large contribution from rivers, especially the Fraser River. Currents rework previously deposited sediments, in particular glaciomarine mud and glacial diamict units, and biogenic carbonate, which accumulates in bedrock and nondepositional areas of low terrigenous input where tidal currents and biological productivity are pronounced. Sponge reefs have developed in deeper water areas where suspended fine sediments are trapped and accumulated by the biological growth of siliceous sponges. In addition to these sources of recent sediments, anthropogenic activities locally contribute sediments as marine dump sites are utilized.*

PGa — ***Anthropogenic deposits:*** *the dredged material found at ocean disposal sites consists of mixtures of silt, sand, rock, wood waste, and other approved material. On the map, two disposal sites are visible: Porlier Pass (49°00.75'N, 123°30.50'W) and Five Finger Island (49°13.86'N, 123°54.95'W). These sites are characterized by irregular intermediate to strong backscatter, forming round and linear backscatter features against a low-backscatter background. The spoil sediments overlie Holocene mud and bedrock.*

PGsr — ***Sponge reefs:*** *massive matrix of organic-rich, olive, slightly sandy-silty clay containing siliceous (glass) sponges (Hexactinellida, Hexactinosida) found as in situ whole skeletons and fragments. On seismic records, the unit appears as 1–3 m high transparent mounds overlying glaciogenic deposits. Very low backscatter strength on top of strong acoustic backscatter characterizes this unit.*

PGs — ***Postglacial sand:*** *sand or muddy sand. The unit is mostly found on the surface of some glacial sediments as it originates from the reworking of these sediments. Seismic profiles show that the unit is thin and can, in most cases, be defined as a veneer, with a distinctive low to intermediate backscatter strength. This unit is best represented in a submarine channel found northeast of Gabriola Island, where the unit infills the channel floor. See cross-section B-B'.*

PGm — ***Postglacial mud (Holocene mud):*** *silty clay; sediments originating from the Fraser River and forming the Fraser River pro-delta. The clay/silt ratio in the unit increases distal to the Fraser River mouth. The unit exceeds 300 m in thickness in the deepest basins and acoustic data are masked by interstitial biogenic gas in some areas. This unit has the weakest, but most uniform acoustic backscatter signal and generally does not show much relief. This unit occupies and dominates the deepest areas of the Straight of Georgia.*

#### GLACIAL SEDIMENTS

*Glacial sediments include all sediments deposited during a glacial episode. Glaciomarine sediments were widely deposited in the Pacific region of Canada when glacial processes delivered sediments to the marine environment. A complex interaction between ice-front position, sea level, and rate of ice advance and retreat governed distribution of these sedimentary facies. During the latest phase of the last (Fraser) glaciation, glaciomarine sediments, mainly mud with a sand and ice-rafted gravel component, were deposited in troughs. These glaciogenic deposits all show strong backscatter strength. Ice-contact sediments resulted in glacial diamictons that have acoustically incoherent signatures on seismic-profile data. In some areas of the Strait of Georgia, including the Gulf Island channels, boulder fields overlie these sediments. The ice-contact deposits are common north of Gabriola Island where the geomorphology of the seafloor reflects glacial depositional processes and the presence of glaciogenic sediments.*

Gmd — ***Glaciomarine ice-distal sediments:*** *well stratified gravelly sandy mud. On seismic profiles, the unit is represented by weak and continuous reflectors draping underlying units and is also characterized by intermediate to strong backscatter. Rare outcrops occur on the seafloor north of Gabriola Island, where exposed glacial deposits are common. In most cases, the unit fills troughs and is buried under thick postglacial mud.*

Gmp — ***Glaciomarine ice-proximal sediments:*** *texturally variable mixture of sediments including mud, sand, gravel, and boulders. In some areas, the unit is acoustically stratified with discontinuous reflectors; elsewhere more acoustically incoherent and disturbed in appearance. The unit is readily defined when it overlies ice-contact sediments. These deposits are widespread north of Gabriola Island. See cross-section A-A'.*

Gmu — ***Glaciomarine sediments (undefined):*** *stratigraphic relationships, setting, seafloor geomorphology and the backscatter strength of the unit share similarities with other recognized glacial units. This unit includes both ice-contact and glaciomarine ice-proximal sediments; however, these cannot be spatially defined because of the lack of geophysical or sample data available. See cross-section B-B'.*

Ic — ***Ice-contact sediments:*** *glacial diamicton till up to 60 m in thickness. This unit has strong multibeam backscatter strength, similar to the bedrock units, but the glacially derived geomorphology and transparent acoustic signature permit discrimination. See cross-section A-A'.*

### PRE-QUATERNARY

*Bedrock outcrops east of, and parallel to the Gulf Islands. Where buried, the bedrock surface can be traced on high-resolution seismic profiles, but is best defined using lower frequency subbottom profilers, where it forms the acoustic basement. The bedrock composing the Gulf Islands is sedimentary rocks of Cretaceous age and is part of the Nanaimo Group. Faults, folds, and other structures common on the Gulf Islands are also apparent in the marine environment.*

uKN — ***Upper Cretaceous sedimentary Nanaimo Group:*** *dominated by layers of sandstone and conglomerate alternating with fine-grained sandstone and mudstone. The group includes several formations with variable sequences and bed thicknesses (Mustard, 1994; England and Bustin, 1998). Acoustically, the unit shows a discontinuous strong backscatter strength character with alternating low backscatter strength areas, resulting from the sharp and pronounced topography. The unit is most definable using the multibeam-sonar bathymetry and sun-illuminated topography.*

*Geological contact (map unit boundaries are interpreted from multibeam-sonar bathymetry and geophysical seismic-profile data and are inferred contacts that may be gradational or conceptual in nature)*
*Fault; defined, approximate*
*Normal fault, defined*
*Oblique thrust fault, defined*
*Submarine channel* — Sc
*Boulder fields* — Bf
*Pockmarks* — P
*Anthropogenic disturbances:*
- *Dredged site* — Ad
- *Log boom* — Al
- *Marina pile* — Am
- *Undifferentiated anthropogenic disturbance* — Au
- *Cable* — Ac

*Seafloor photograph (see Figures 2–7)*

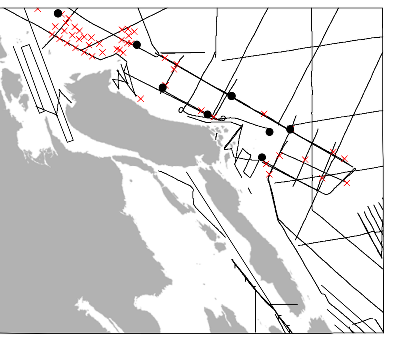

Figure 8. Survey tracklines and sample data collected between 1999 and 2004.

*Video from ROPOS and submarine dives*
*Sediment grab sample locations*
*Subbottom and/or sidescan sonar tracklines*


Copies of this map may be obtained
from the Geological Survey of Canada:
615 Booth Street, Ottawa, Ontario K1A 0E9
625 Robson Street, Vancouver, British Columbia V6B 5J3
490, rue de la Couronne, Québec, Quebec G1K 9A9
1 Challenger Drive, P.O. Box 1006, Dartmouth, Nova Scotia B2Y 4A2


LOCATION MAP


**Author: K. Picard**


*Geology by K. Picard, 2004–2008*

*Digital cartography by R.F. MacLeod, GSC (Pacific)*

*Any revisions or additional geological information known to the user would be welcomed by the Geological Survey of Canada*

MAP 2118A

SURFICIAL GEOLOGY AND SHADED SEAFLOOR RELIEF

# NANAIMO

BRITISH COLUMBIA

Scale 1:50 000/Échelle 1/50 000

Universal Transverse Mercator Projection
North American Datum 1983

Projection transverse universelle de Mercator
Système de référence géodésique nord-américain 1983



*Digital base map from data compiled by Geomatics Canada, modified by GSC (Pacific)*

*Digital bathymetric contours in metres supplied by the Canadian Hydrographic Service and GSC (Pacific)*

*Magnetic declination 2010, 17°40'E decreasing 12.0' annually*

*Depth in metres below mean sea level*


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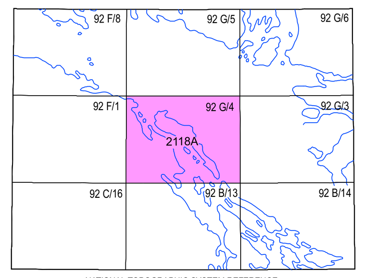

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