UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

BEDROCK GEOLOGIC AND QUATERNARY TECTONIC MAP OF THE PORT TOWNSEND AREA, WASHINGTON

by

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This report is preliminary and has not been reviewed for conformity with the U.S. Geological Survey editorial standards and stratigraphic nomenclature.

INTRODUCTION

This study was undertaken as part of a seismotectonic analysis of the Puget Sound region. The principle purpose of mapping the bedrock geology was to identify major bedrock faults. However, since most of the area is covered by water or a thick section of Quaternary glacial deposits, aeromagnetic and gravity anomalies were analyzed to identify possible unexposed structures. In addition logs of the few deep water and petroleum test wells drilled in the area were studied for further information on subsurface stratigraphy and structure.

The location of faulted or folded Quaternary deposits are shown on the map and described in table 1. Only deformation which is considered to be of possible tectonic origin is shown. Soft-sediment deformation that could best be explained by glacial activity or features that appear to be related to slope failure are not included. It should be recognized, however, that the forces resulting from the thick ice that overrode the area several times during the Pleistocene epoch could have formed structures not readily distinguishable from those formed by tectonic deformation and some of the faulted or folded Quaternary deposits shown here may not be true tectonic structure.

The structures inferred from interpretation of linear aeromagnetic and gravity anomalies are shown on the bedrock geologic and Quaternary tectonic map and on figure 3 and are described in table 2. Geophysical anomalies, however, may owe their origin to geologic processes other than faulting. Gravity anomalies result from juxtaposing rocks of differing density and thickness and magnetic anomalies result from juxtaposing rocks of different magnetic susceptability. Such relationships, although commonly formed by

faulting, can also be formed by steep folding or nontectonic means such as abrupt changes of lithologic facies (rock composition).

Several previous reports describe the geology of parts of the Port Townsend area. Regional geologic studies by Weaver (1916 and 1937) covered the southern part of the area. Durham (1944) describes the stratigraphy and presents a generalized bedrock geologic map of the Port Discovery-Marrowstone Island area. Later the same area was further studied by Allison (1959) and Thomas (1959). More recently the area south and west of Anderson Lake was included in the Geologic map of the Olympic Peninsula by Tabor and Cady (1978). Armentrout and Berta (1977) described the stratigraphic distribution of foraminifera. Structures inferred from marine seismic reflection profiles and other geophysical data are described by Wagner and Wiley (1980). Parke D. Snavely's contributions in the field and through discussions and James P. Minard's assistance in collecting auger samples are gratefully acknowledged. Weldon W. Rau provided valuable data on the age and depositional environments of foraminifera.

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Table 1.--Localities of Quaternary folding and faulting

Map number	Description of deformation	Age of deformed sediment[1]	Reference
1	Tilted stratified clay and silt cut by numerous small normal faults with as much as 40 cm. displacement.	Pre-Fraser	Fred Pessl, oral communication, 1977
2	Several east-striking, north-dipping thrust faults in stratified glacial deposits.	Fraser or Post-Fraser	Gerald W. Thorsen oral communication, 1980
3	Numerous normal faults in stratified sand and silt exposed in lower part of sea cliff. Faults strike east and have displacements as much as 5.5 m. Overlying Fraser? Age glacial deposits in upper part of cliff appear to be undeformed.	Pre-Fraser	Gower, 1978
4.	Several west trending folds in stratified sand and silt exposed in wave cut bench and lower part of sea cliff. Limbs of folds dip up to 7°. Overlying Fraser aged glacial strata in upper part of sea cliff appear to be undeformed.	Pre-Fraser	Gower, 1978
5.	Gentle arching of iron-stained gravel and sand overlain by undeformed Fraser glacial outwash deposits.	Pre-Fraser	Gower, 1978
6.	Normal fault striking N. 50° W, and dipping 68° NE. Offsets glacial outwash gravel and sand about 2 meters, down on northeast side.	Fraser or Post-Fraser	Gower, 1978
7.	East-striking, north-dipping thrust fault in stratified glacial deposits.	Fraser or Post-Fraser	Gerald W. Thorsen, oral communication, 1980

[1] Age of Fraser glaciation is dated at approximately 10,000 to 18,000 years B.P. (Easterbrook, 1969).

Table 2.--Structures inferred from interpretation of linear geophysical anomalies. Structures are shown on the geologic and Quaternary tectonic map and figure 3.

Inferred structure	Description	References
B	East-trending gravity nose bounding the north side of a large gravity low to the southeast. Coincides with linear alignment of series of small magnetic lows. This anomaly appears to bound pre-Tertiary metamorphic rocks at or near the surface on northern Whidbey Island from a thick section of unconsolidated Quaternary deposits, estimated to be nearly 1600 feet thick in U.S. Naval Air Station well No. 4 on the south (see table 3). It may also form the northern boundary of a basin of Tertiary sedimentary rocks to the south. Where it crosses Whidbey Island anomaly B is inferred to mark the trace of the Northern Whidbey Island fault. Deformed pre-Fraser glacial deposits on the east side of Whidbey Island (table 1, #1) suggest that this inferred fault may have been active in Quaternary time.	U.S.G.S., 1977; Rogers, 1970 Gower, 1978; MacLeod and others, 1977.
C and D	A pronounced linear magentic high extending southeast from near Victoria on Vancouver Island. Has been interpreted as a northeast-dipping slab of lower to middle Eocene Metchosin (Crescent Formation) volcanics bounded on both sides by faults (structures C and D). MacLeod and others (1977) consider C the offshore continuation of the Leech River fault of Vancouver Island.	MacLeod and others, 1977.
F	North edge of high amplitudes magnetic anomaly bounding volcanic rocks of the Crescent Formation, locally overlain by thin section of Tertiary sedimentary rocks, on the south from a thick section of Tertiary sedimentary rocks on the north. Interpreted as fault with the north side down.	U.S.G.S., 1977
G	Linear magnetic high and southern boundary of a pronounced gravity low. Interpreted as northwest-trending fault, the Southern Whidbey Island fault, of probable Quaternary age. Evidence for Quaternary displacement on this inferred fault is: 1) large difference (1374 feet) in depth to bedrock on opposite side of fault as observed in Standard Oil Company of California wells (see table 3); and 2) high resolution seismic reflection profile evidence for Holocene faulting on the northwest end of this structure in Admiralty Inlet (Wagner and Wiley, 1980).	U.S.G.S., 1974, 1977; Gower, 1978.

Table 3.--Oil and gas exploration and deep water wells shown on Bedrock geologic and Quaternary tectonic map.

Name	Total Depth	Depth to base of Quaternary (feet)	Description	Reference
U.S. Naval Air Station Water well No. 4.	1933	1655	Base of Quaternary interpreted from lithologic description in drillers log. Lower 278 feet of well drilled in sandstone, shale and clay of probable Tertiary age.	Anderson (1968) p. 255-256
Standard Oil Co. of California, Engstrom Community No. 1.	7353	2050	Base of Quaternary interpreted from lithologic description in drillers log and electric logs. Quaternary deposits overlie interbedded sandstone, siltstone and mudstone of probable Tertiary age. Abundant fossil shells below 3190 feet depth suggest that most of these rocks are marine.	Anderson (1968) p. 32 and 218-221.
Standard Oil Co. of Californnia Pope and Talbot No. 3-1.	4375	676	Base of Quaternary interpreted from lithologic description in drillers log and electric logs. Quaternary deposits overly probable marine Tertiary sedimentary rock comprised of interbedded sandstone, siltstone and claystone with abundant fossil shells.	Anderson (1968) p. 32, 226 and 227.

DESCRIPTION OF MAP UNITS

(Shown on map and/or figures 1 and 2)

af ARTIFICIAL FILL

Qb BEACH DEPOSITS--Sand, gravel and silt. Deposited on beaches and spits. Locally includes marsh deposits.

Qg GLACIAL DEPOSITS--Slumped, chaotic debris composed of local bedrock. Arrows show direction of movement.

Qu UNDIFFERENTIATED QUATERNARY DEPOSITS--Includes glacial outwash, till, beach, alluvium, and marsh deposits and artificial fill.

Tms MARROWSTONE SHALE of Durham (1944)--Siltstone, sandy siltstone and silty fine-grained sandstone, medium gray, massive to faintly bedded, with occasional thin (4 to 10 cm) well sorted fine-grained sandstone beds. Locally contains calcareous concretions (up to 30 cm in diameter) and lenses up to 3 meters long). Foraminifera from this unit indicate an outer shelf depositional environment and are assigned to the Refugian foraminiferal stage (W. W. Rau, oral communication, 1980).

Tq QUIMPER SANDSTONE of Durham (1944)--Sandstone, gray to olvie gray, weathers to yellowish brown, fine- to coarse-grained, poorly sorted, feldspathic. Most commonly is faintly bedded to massive, but includes some thin bedded to laminated sections and occasionally is cross-bedded. Locally contains siltstone beds up to 12 cm thick, spherical and elyptical calcareous concretions up to 30 cm in diameter, and calcareous lenses up to 4 meters long. Also contains rare isolated well rounded chert pebbles. Marine mollusks collected from this unit are assigned an Oligocene age by Durham (1944).

Tc CONGLOMERATE--Pebble and cobble, massive to thick bedded. Clasts are predominantly chert, with some metasandstone, quartz and minor gabbro and granite; locally well cemented with calcium carbonate. Unconformably overlies Lyre Formation and older rocks south of Sunset Lake. Its age and correlation with post Lyre Formation rocks to the north are uncertain (see figure 1).

LYRE FORMATION divided into:

Tlu Upper part--sandstone, massive to thin bedded, very fine to medium grained, pebbly. Also includes pebble and cobble conglomerate, siltstone and sandy siltstone.

Tlus Siltstone and sandy siltstone--Thin to very thin bedded. Locally includes thin beds of fine- to coarse-grained sandstone and grit. Includes Townsend Shale of Durham (1944) north of Woodmans on Discovery Bay.

Tluc Conglomerate--Pebble to cobble, thick bedded, clasts predominantly chert with minor white to yellowish gray andesite clasts presumably derived from underlying Tav.

Tll Lower part--Conglomerate, sandstone and siltstone. Conglomerate clasts are predominantly chert with metasedimentary and metaigneous rocks, quartz and graywacke. Sandstone ranges from fine to very coarse grained and commonly contains scattered pebbles. Siltstone is sandy and thin to faintly bedded.

Tav ANDESITIC VOLCANIC ROCKS--Andesite and hornblende andesite tuff and breccia, white to light gray. Locally contains rare leaves and coalified wood. Commonly massive, but some tuffs are thin bedded. Outcrop area shown in NW 1/4 of section 16 on figure 1 is inferred from presence of scattered angular clasts of hornblende andesite float.

Tai ANDESITE--Pale yellowish brown, porphyritic intrusive or massive flow. Only exposed on Skunk Island where it appears to be in fault contact with Quimper Sandstone of Durham on south side of the island.

Tu UNDIFFERENTIATED TERTIARY ROCKS--Only exposed northeast of Anderson Lake (Fig. 1) where it consists of fine- to very coarse-grained semifriable sandstone with thin lenses of pebble conglomerate with abundant yellowish gray to white tuff clasts. Age and correlation with other units is uncertain.

Teu SEDIMENTARY ROCKS, UNNAMED (Middle to early Eocene--Sandstone, fine- to medium-grained, feldspathic, thin to thick bedded, locally contains rounded shale clasts up to 10 cm long. Convolute bedding is common and the base of many beds contain grove casts. Thick sandstone beds are cavernous weathering. Sandstone is interbedded with massive to faintly bedded, dark gray to black siltstone. Foraminifera indicate a middle to lower Eocene age for these rocks. They have been assigned to the Ulatesian and possibly Penutian foraminferal stages by Thomas (1959), and Rau, oral communication, (1980).

Teuv VOLCANICLASTIC ROCKS--Dark gray to black, basaltic tuff, sandstone and tuffaceous siltstone. Thin to faintly bedded. Some sandstone shows large scale cross-bedding. Sandstone is composed of very fine- to grit-sized angular clasts of aphanitic basalt and devitrified glass. Thick tuffaceous siltstone beds show spheroidal weathering. Volcaniclastic unit is about 21 meters thick where exposed on east side of Indian Island.

Teub BASALT--Microcrystalline to coarse grained. It is poorly exposed in several isolated locations north of Sunset Lake. It could not be determined if the basalt is extrusive or intrusive and its relationship to closely associated Teu sedimentary rocks is uncertain.

CRESCENT FORMATION divided into:

Tevc Conglomerate--Massive to faintly stratified, well rounded boulder and cobble conglomerate composed of basalt clasts. Commonly highly weathered. Overlies about 6 meter thick red saprolite exposed in highway road cut along east side of Port Discovery. The basaltic conglomerate east and south of Moon Lake is tentatively assigned to this unit, but it is poorly exposed and its stratigraphic position is uncertain.

Tev Basalt--Massive flows and breccia with very rare pillow lavas. Some thick flows are columnar jointed. Red oxidized zones at tops of flows are common. Most of the exposed part of this unit in the mapped area appears to be subareal.

Tbi BASALT INTRUSIVES--Massive fine- to coarse-grained basalt dikes up to 25 feet thick intruding Tev sedimentary rocks on Indian and Marrowstone Islands.

pTu PRE-TERTIARY ROCKS--Foliated sandstone and argillite with some conglomerate. Typically green to greenish gray and thin bedded.

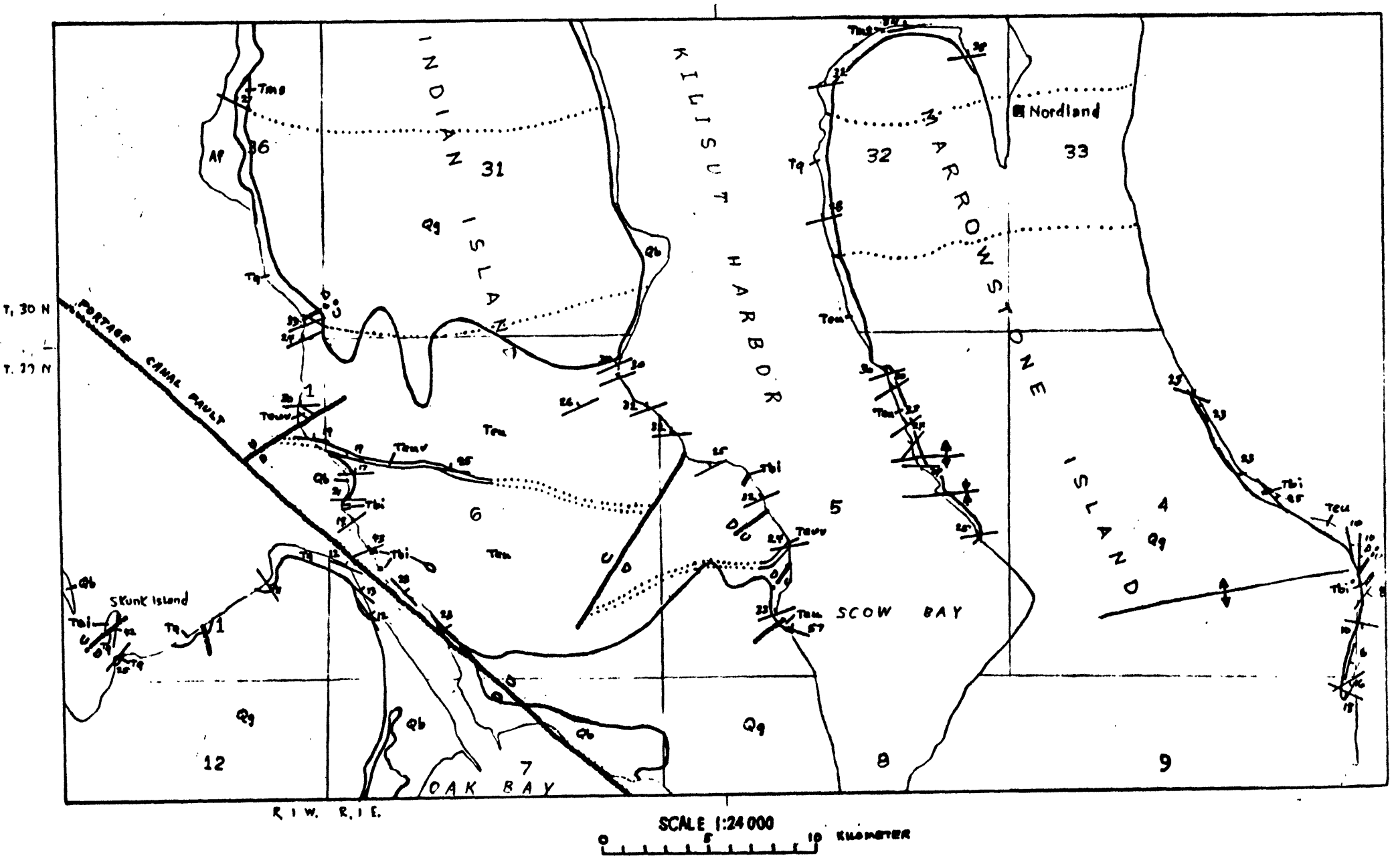


FIGURE 2. GEOLOGIC MAP OF THE INDIAN ISLAND - MARROWSTONE ISLAND AREA

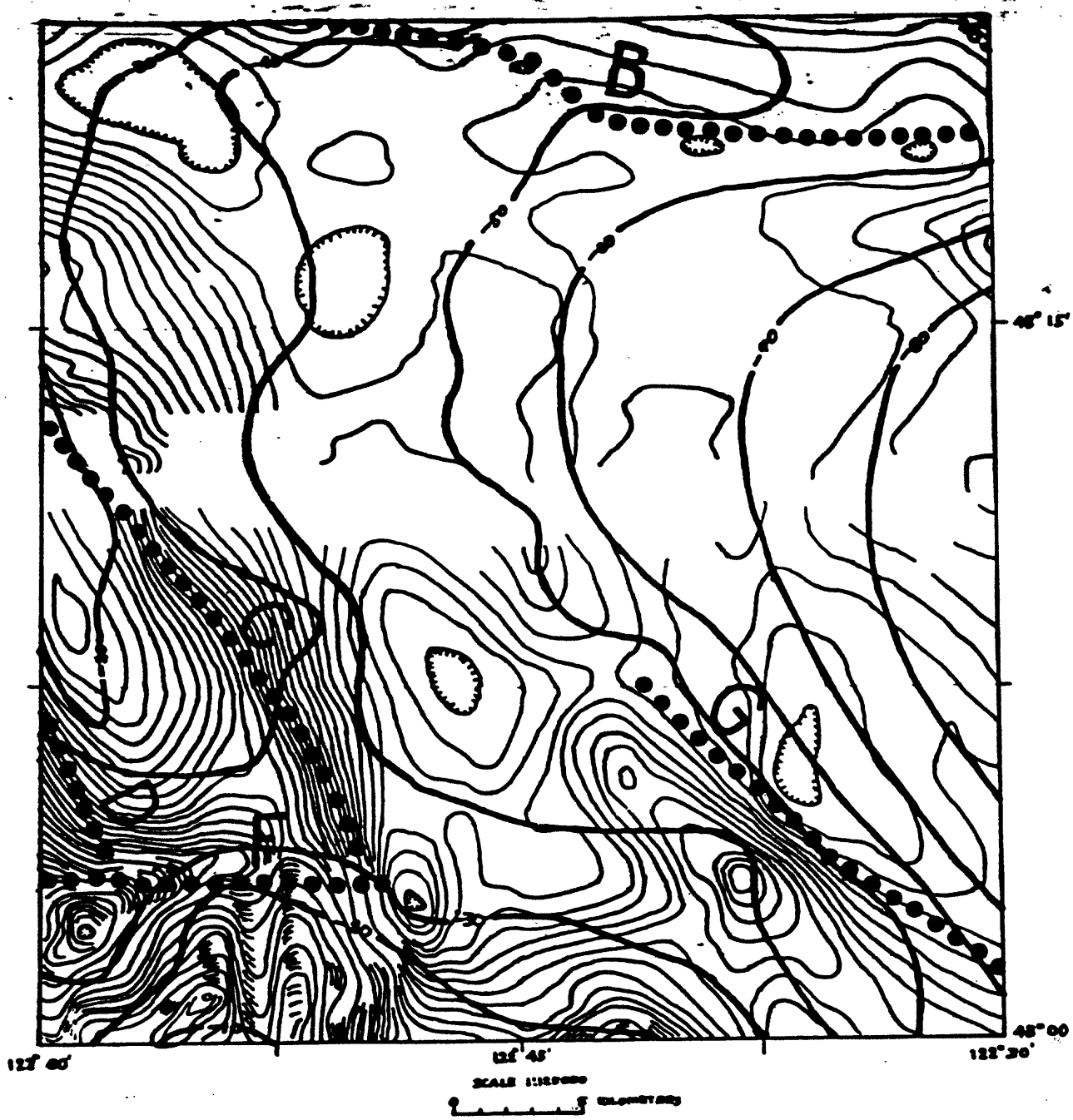
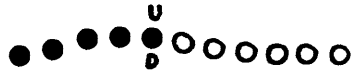


FIGURE 3. Simple Bouguer gravity and aeromagnetic anomaly maps. Gravity contours (thick line) in milligals. Magnetic contours (thin line) at 20 gamma intervals. Gravity modified from Blakely and others (1978 and Stuart (1965) Magnetic data from U.S. Geological Survey (1974) and (1978).

EXPLANATION

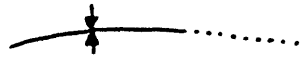
Contact, approximately located
Dotted where concealed or inferred

Fault, approximately located
Dotted where concealed. U, upthrown side; D, down thrown side



Inferred structure
Inferred from gravity, aeromagnetic or subsurface well data. May represent sharp fold or abrupt facies change rather than fault. U, apparent upthrown side; D, apparent downthrown side. Open circles indicates possible Quaternary movement

Anticline, approximately located
Showing trace of axial plane and bearing and plunge of axis



Syncline, approximately located
Showing trace of axial plane. Dotted where inferred

Strike and dip of beds

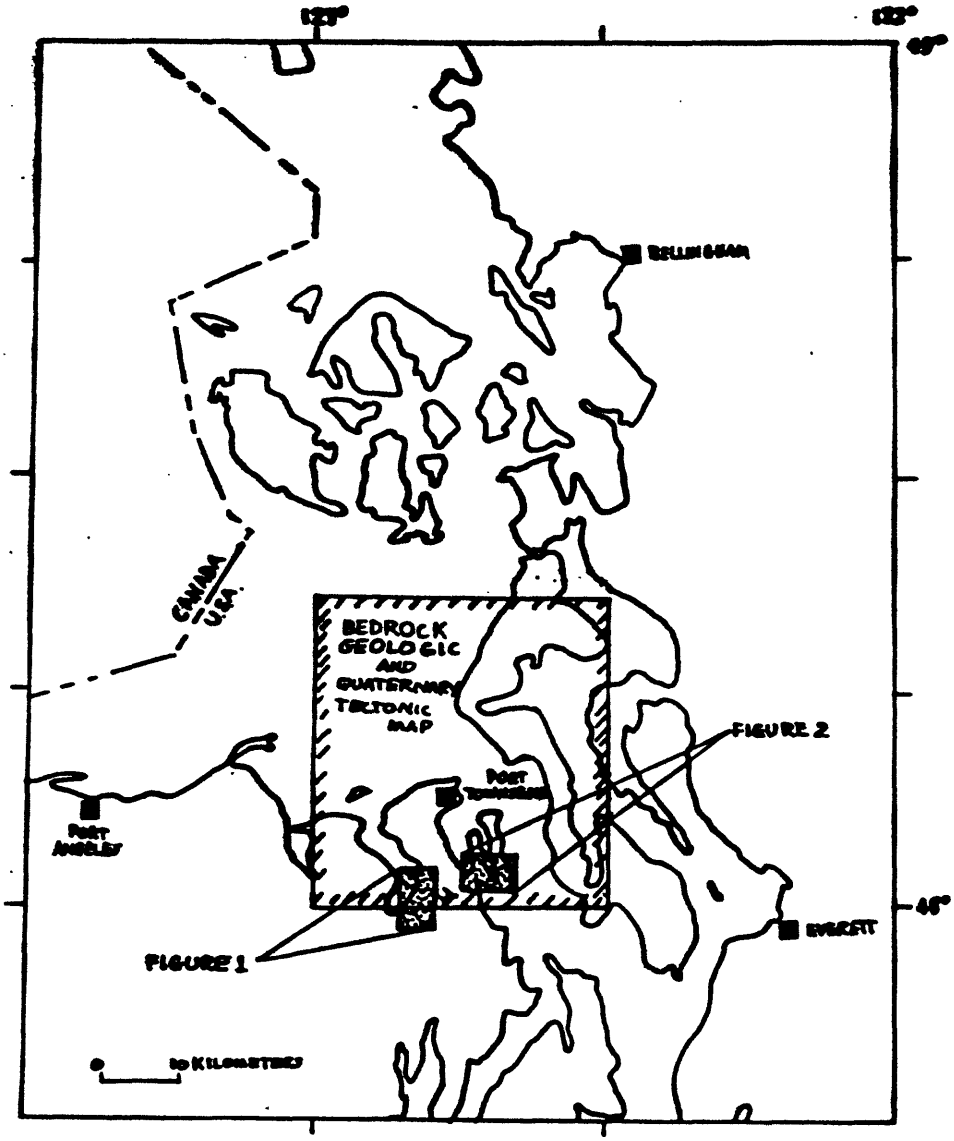
Horizontal beds

Strike and dip of vertical beds

Strike and dip of overturned beds

Quaternary fault or fold
Number refers to table 1

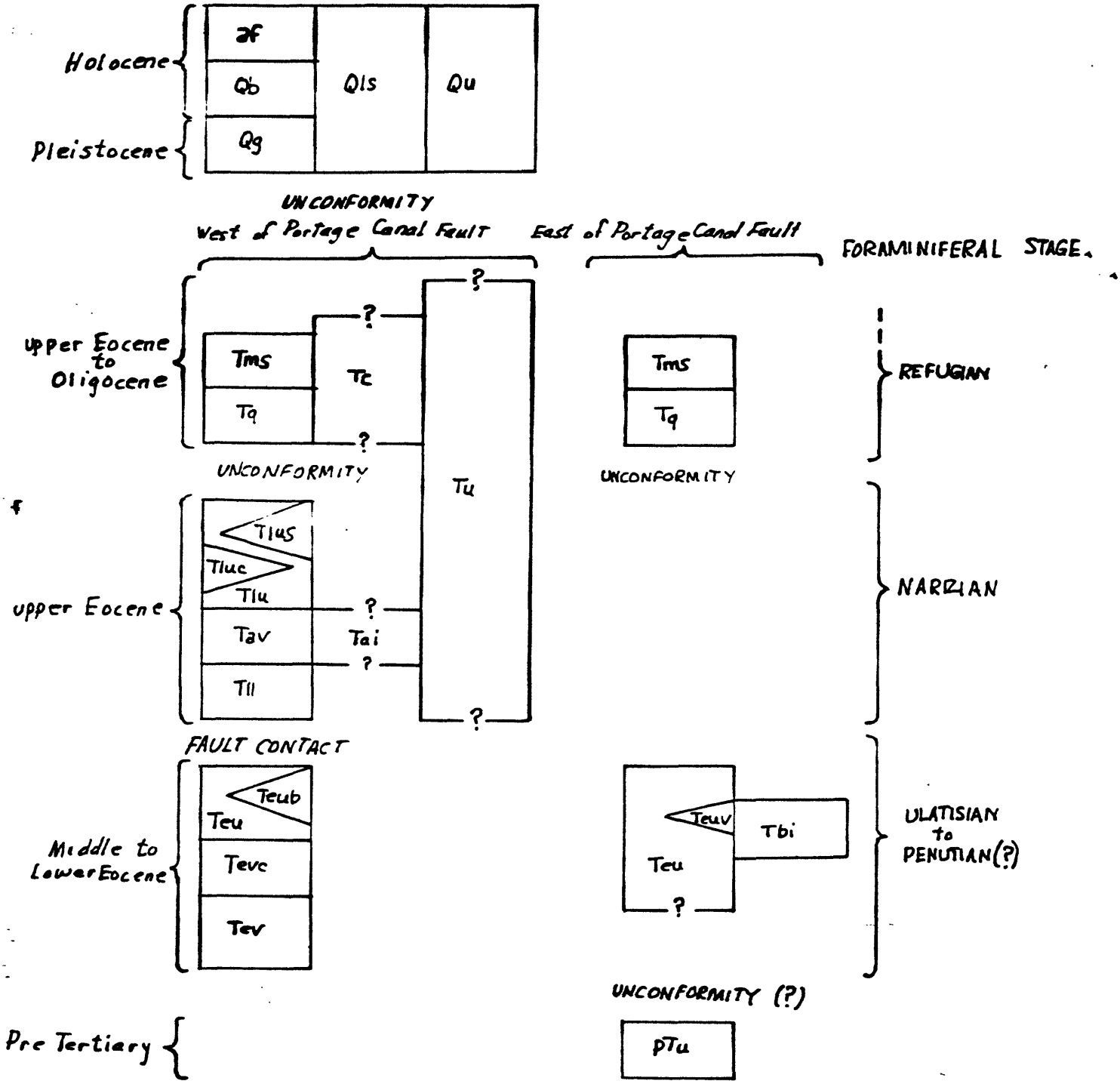
Oil exploration or deep water well


BEDROCK
GEOLOGIC
AND
QUATERNARY
TECTONIC
MAP
CANADA
U.S.A.
FIGURE 2
FIGURE 1
EVERETT
46°

INDEX MAP

CORRELATION OF MAP UNITS

(Shown on Geologic and Quaternary tectonic map, Figure 1, and Figure 2)



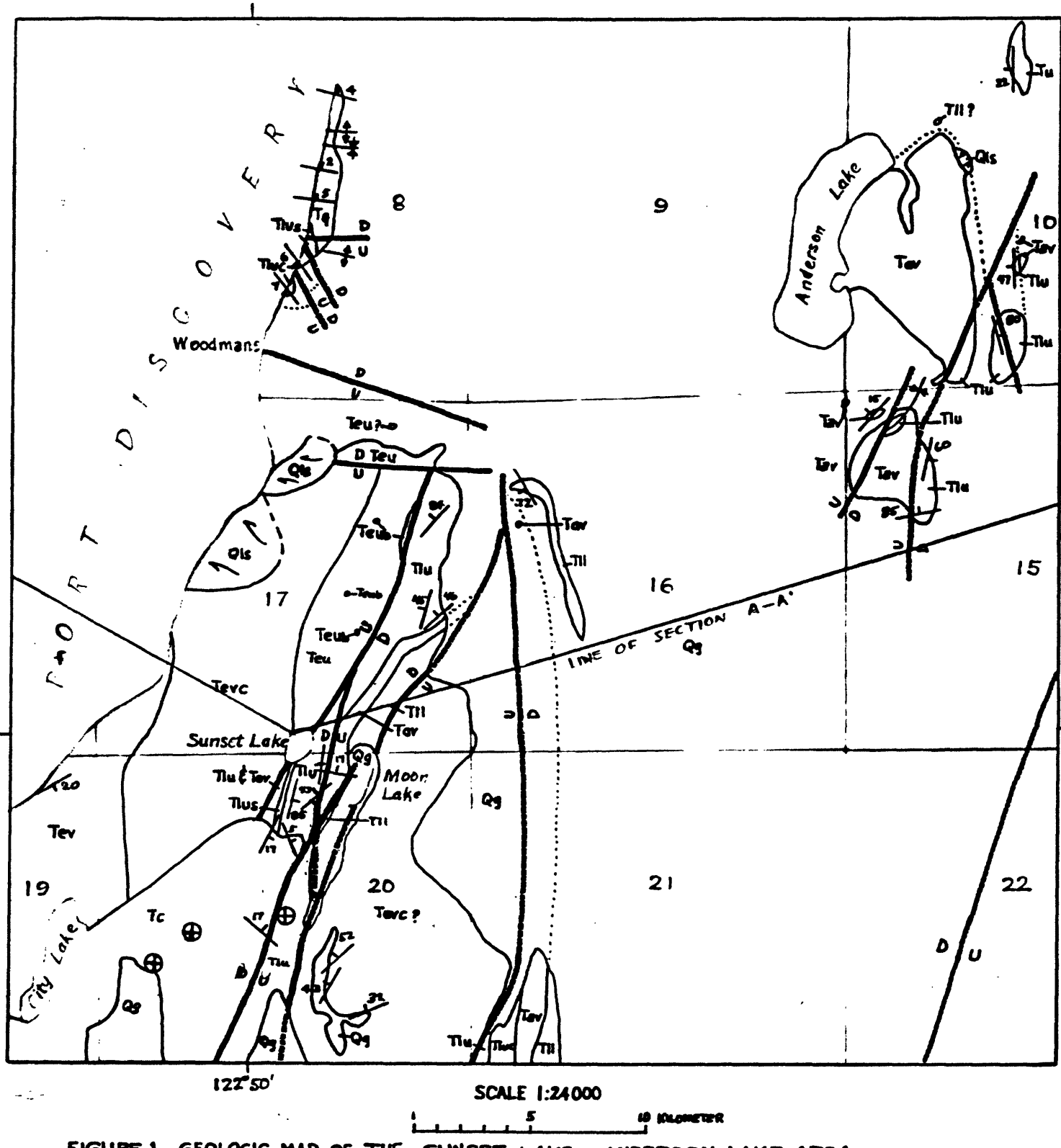


FIGURE 1. GEOLOGIC MAP OF THE SUNSET LAKE - ANDERSON LAKE AREA