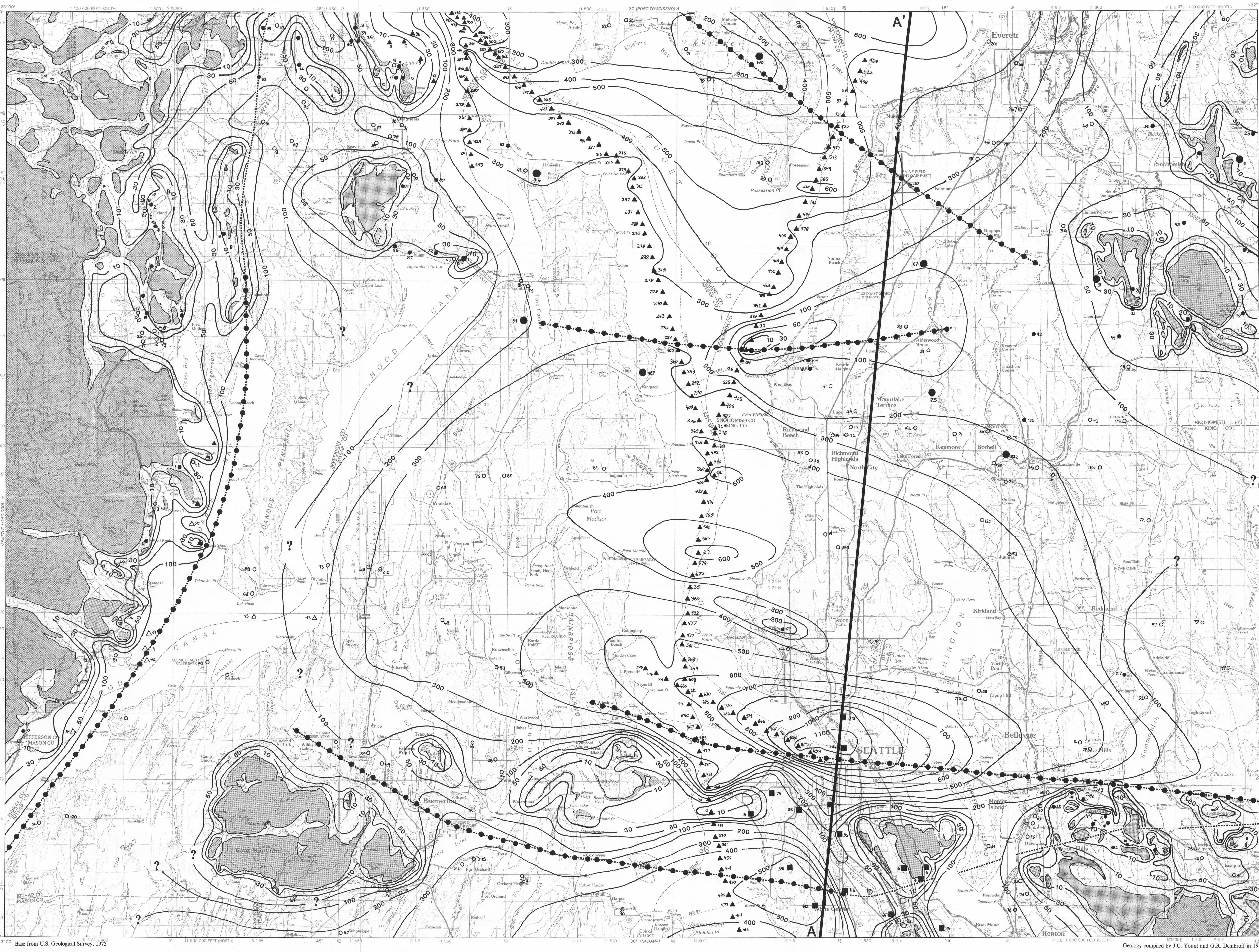
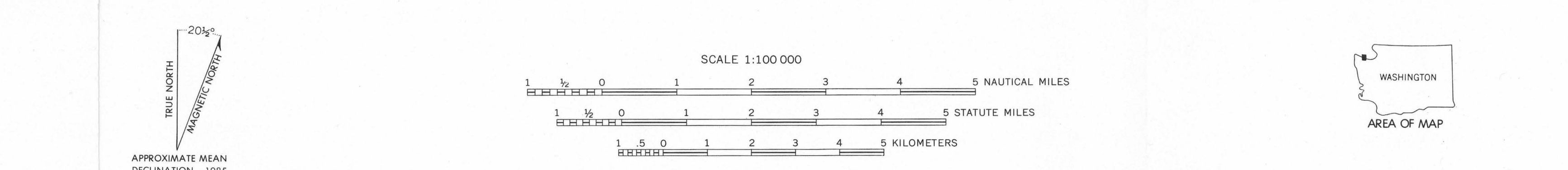
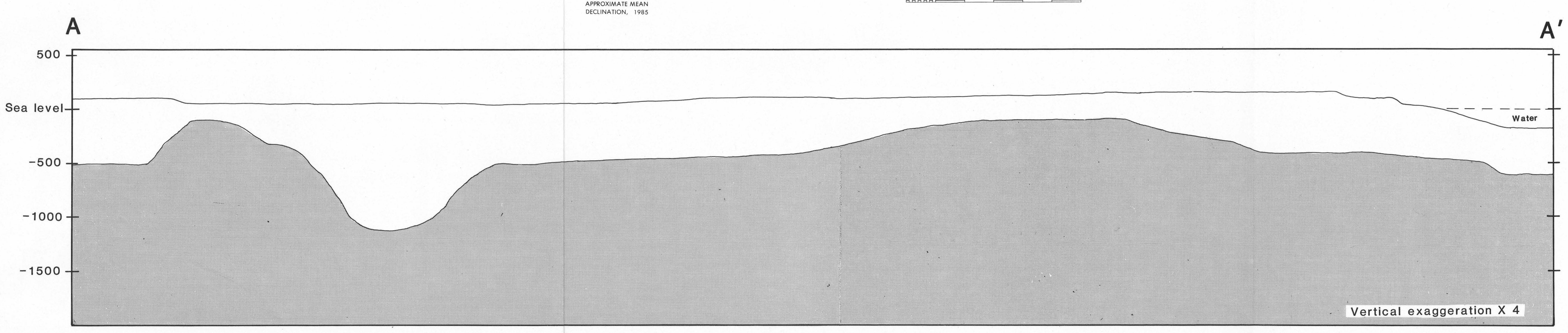
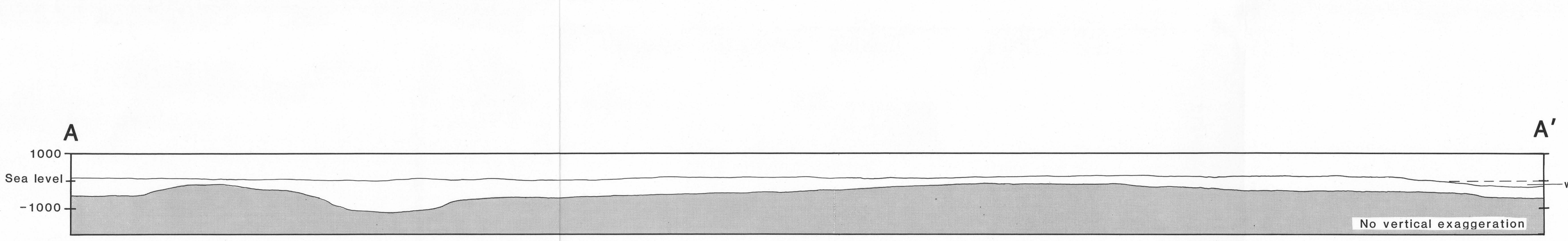


Base from U.S. Geological Survey, 1973

Geology compiled by J.C. Yount and G.R. Dembroff in 1981







MAP SHOWING DEPTH TO BEDROCK IN THE SEATTLE 30' by 60' QUADRANGLE, WASHINGTON

By
James C. Yount, Glenn R. Dembroff,
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1985

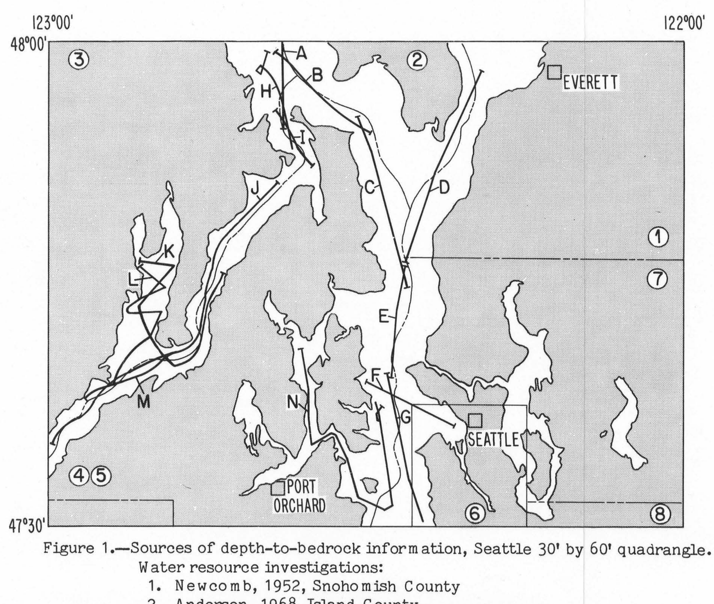

Figure 1.—Sources of depth-to-bedrock information, Seattle 30' by 60' quadrangle.

Water resource investigations:
1. Newcomb, 1952, Snohomish County
2. Anderson, 1968, Island County
3. Grimstad and Carson, 1981, eastern Jefferson County
4. Garling and others, 1965, Kitsap County
5. Sceva, 1957, Kitsap County
7. Liesch and others, 1963, northwestern King County
8. Luzier, 1969, southwestern King County

Geotechnical investigations:
6. Yount, 1983

Marine seismic investigations:
A. Western Geophysical line Pg. 71-20
B. Western Geophysical line Pg. 71-21
C. Western Geophysical line Pg. 71-22
D. Western Geophysical line Pg. 71-23
E. Western Geophysical line Pg. 71-25
F. Western Geophysical line Pg. 71-26
G. Western Geophysical line Pg. 71-27
H. USGS high-resolution line
I. Western Geophysical line Pg. 71-42
J. USGS high-resolution line
K. USGS high-resolution line
L. USGS high-resolution line
M. USGS high-resolution line
N. USGS high-resolution line

EXPLANATION

AREA OF BEDROCK OUTCROP

—100— CONTOUR SHOWING DEPTH TO BEDROCK, IN METERS

MAJOR STRUCTURAL OR GEOPHYSICAL LINEAMENT—From Gower and Yount (in press)

SOURCES OF DATA—Solid symbol, reached bedrock; open symbols, did not reach bedrock
- ● ○ Water well
- ■ □ Geotechnical well
- ▲ △ Marine seismic reflection profile
- ● Oil or gas well

INTRODUCTION

Maps depicting thicknesses of sedimentary units (isopach maps) are standard tools for interpretation of processes and patterns of sedimentation within basins (Potter and Pettijohn, 1977, p. 283-287). Isopach maps showing the thickness of unconsolidated sedimentary deposits overlying bedrock may help locate sources of aggregate and potential ground-water aquifers. These maps also aid in the prediction of ground response resulting from earthquakes (Hays, 1980). In the Puget Lowland this latter use is of particular importance. Strong ground motions were highly variable throughout the Puget Sound area during the 1965 Seattle earthquake ($M_s = 6.5$); complex topography of the bedrock surface plus thick sections of young unconsolidated and semiconsolidated sediment were responsible for this variability (Langston, 1981; Shakel and Toksoz, 1980). Hall and Othberg (1974) outlined the major patterns of unconsolidated sediment accumulation in Puget Sound, including the unusually thick sedimentary deposits beneath the city of Seattle.

Since Hall and Othberg's 1974 study, new geotechnical drilling and marine seismic reflection profiling information have become available and were used to prepare this map, which shows the depth to bedrock in the Seattle 30' by 60' quadrangle (scale 1:100,000). The map shows bedrock depth, in meters, beneath the land surface or the sediment-seawater interface.

Bedrock throughout the Seattle quadrangle is presumed to be volcanic rock, conglomerate, sandstone, or shale and is Tertiary in age. With the exception of a few reports of age or lithology collected from oil wells (Livingston, 1958), the subsurface information used for this map sheds little light on the nature and distribution of the various Tertiary rocks in the subsurface. It is assumed, on the basis of pronounced lithologic differences in drill holes and widespread unconformable relationships with underlying bedrock units seen in marine seismic reflection profiles, that the deposits overlying bedrock are Quaternary in age, but no direct dating of materials has been done to confirm this assumption.

ACKNOWLEDGMENTS

We thank Al Kilian and LeRoy Wilson of the Washington State Department of Transportation Materials Laboratory for their help in locating borehole information. The City of Seattle Engineering Department and Barry Lipnick, in particular, provided valuable assistance in gaining access to data from subsurface investigations of many of Seattle's building sites. Terry Olmstead of Shannon and Wilson, Inc. and Dennis Stettler of Hart Crowser and Associates, Inc. suggested sources of subsurface data for the suburban Seattle area. We also thank Western Geophysical for permission to publish information derived from their proprietary seismic lines in Puget Sound. Fred Pessl, Jr., of the U.S. Geological Survey (USGS) in Seattle freely shared depth-to-bedrock information from the adjoining Port Townsend 30' by 60' quadrangle (scale 1:100,000). Reviews by John Tinsley and Ed Helley, U.S. Geological Survey, improved the map and text to a large degree.

DATA AND ASSUMPTIONS

Drill-Hole Information: Depth to bedrock is derived from three types of drilling information: water well logs, exploratory oil or gas well logs, or logs from geotechnical boreholes. State and Federal investigations of water resources of various Puget Sound counties provide the majority of the water-well information used in this study (fig. 1). Oil and gas information comes from Livingston (1958) and is supplemented by inspection of drilling reports filed with the State of Washington, Division of Mines and Geology. Geotechnical drilling information is usually unpublished and was gathered by inspection of logs for highway structures (primarily bridges), major buildings, and subsurface investigations for tunnels or underground water and sewer lines.

Accurate determination of sediment thickness overlying bedrock from drill-hole information is difficult in areas underlain by late Tertiary sedimentary rock. This problem is particularly difficult along Tarboo Creek, in the northwest part of the area, and northwest of Issaquah, in the southeast corner of the map, where semiconsolidated Tertiary sandstone and minor conglomerate are overlain by Quaternary sediment of similar lithology and consolidation. Fortunately, much of the map area is underlain by volcanic rock or well-indurated sandstone and conglomerate and the distinction between bedrock and overlying sedimentary deposits is straightforward.

Marine seismic information: Reconnaissance marine seismic surveys using high-resolution Uniboom or mini-sparker energy sources have revealed bedrock at or near the sediment-seawater interface in a number of scattered localities within the map area (fig. 1; Snavely and others, 1976, 1977). In addition, processed 48-channel seismic reflection profiles utilizing high-energy air-gun sources surveyed by Western Geophysical in 1971 provide valuable closely spaced information in many of the major waterways of Puget Sound (fig. 1). Thickness of sediment overlying bedrock is calculated from both high-resolution and multichannel information on the basis of an assumed seismic velocity of 1800 m/s in the sediments.

Bedrock, interpreted from high-resolution seismic reflection records in Hood Canal, appears as a high-amplitude return from an irregular surface with no apparent internal reflectors. Nearby basalt outcrops and lack of stratification suggest that the bedrock detected in Hood Canal is also basalt. The bedrock interface west of Seattle is represented by a marked unconformity between underlying slightly to moderately folded sedimentary and volcanic rocks and overlying poorly bedded to well-bedded flat-lying sediments. These undeformed sediments are presumed to correlate with the unconsolidated Quaternary section penetrated in nearby drill holes. Outcrop information and limited lithologic descriptions from some exploratory oil wells confirm that bedrock beneath the unconformity is mostly Oligocene and Eocene marine sandstone, shale, and conglomerate with some interbedded andesite and basalt.

Aeromagnetic information: Aeromagnetic coverage of Puget Sound (U.S. Geological Survey, 1974, 1977) was used to infer the near-surface presence of volcanic rocks in the area west of the Hood Canal bridge and in the Snohomish River Valley south of Snohomish. No attempt was made to calculate depth of magnetic sources, but contouring of drill-hole data was influenced by the presence of relatively high magnetic intensities in areas where drill-hole information was lacking.

DISCUSSION

The bedrock surface beneath the Seattle quadrangle shows striking relief in contrast to the subdued topography of the modern Puget Lowland (section A-A'). Young unconsolidated and semiconsolidated sediments are thickest in the Seattle area and in the region northwest of Everett. The sediments thin noticeably under the south end of Whidbey Island, near Edmonds, and in the Chittenden Locks area in northern Seattle, as well as in the vicinity of bedrock outcrops around the borders of the quadrangle. The bedrock highs in the Edmonds and Chittenden Locks regions have not been previously recognized. Additionally, depth to bedrock is generally as much as 400 m less in Admiralty Inlet than previously shown (Hall and Othberg, 1974). This pattern mimics the medium-scale features depicted by Bouguer gravity maps of Puget Sound (Daneš and others, 1965; Rogers, 1970), on which bedrock deeps are associated with relative gravity lows and bedrock highs are usually coincident with gravity highs. The unconsolidated sediment is either too dense or not thick enough, however, to explain the entire gravity anomaly in the Seattle and Everett lows (Daneš and others, 1965). This observation indicates that thick sections of Tertiary sedimentary rocks make up much of the underlying bedrock in these areas of low Bouguer gravity.

Steep depth-to-bedrock gradients closely coincide with major geophysical lineaments which have been interpreted as faults (Gower and Yount, in press). Apparently, Quaternary sedimentation patterns are influenced by these structures and suggest that differential vertical motions have taken place during the past 2 million years. Such vertical motions could be tectonic, with faulting along the major west-trending structure that bounds the south side of the Seattle low and with uplift along the southern Whidbey Island and Edmonds highs. The vertical motions also could be accounted for by differential compaction of unconsolidated sediments across previously existing Tertiary bedrock topography. Repeated glaciation of the Puget Trough (Crandell and others, 1958) may have selectively eroded sections on bedrock highs and deposited material in the lows to further enhance the coincidence of Tertiary structures and young sedimentation patterns.

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