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FIDALGO ISLAND FIELD TRIP

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NWGS FIELD TRIP GUIDEBOOK SERIES

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NORTHWEST GEOLOGICAL SOCIETY FIELD GUIDEBOOK SERIES
Field Trip Guidebook #043

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FIDALGO ISLAND FIELD TRIP

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I. INTRODUCTION

This field trip inspects pre-Cenozoic rocks on Fidalgo Island (Fig. 1) in northwestern Washington. Fidalgo Island is the southeasternmost of the major San Juan Islands.

The trip utilizes Brown et al. (2007).

Brown et al. (2007) described most of the rocks on Fidalgo Island as an ophiolite complex. Figure 2 is a schematic diagram of an ophiolite complex. One of the challenges of this trip is to decide which rocks on Fidalgo Island are truly ophiolitic. At the end of the day, note which parts of an ophiolite complex we did and did not see.

The second and associated challenge is to determine how many separate tectonic episodes/events are present. In other words, which rocks are related and which are not. The unconformities shown in the explanation to Figure 1 provide partial answers.

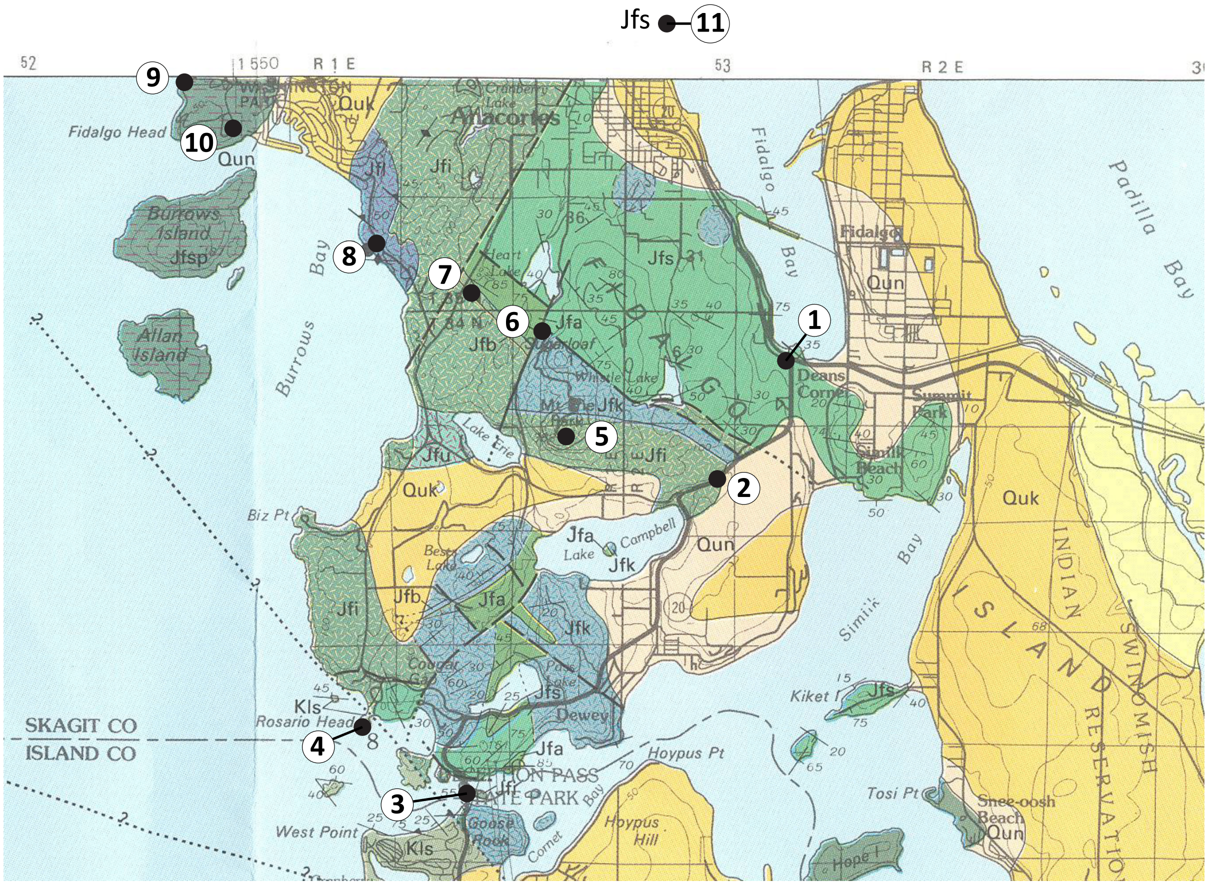
The trip begins southeast of Anacortes, WA, at the junction of SR 20 and SR 20 Spur (the Spur leads to the San Juan Island ferry terminal southwest of Anacortes). The trip ends in Anacortes.

II. REGIONAL AND GENERAL GEOLOGY

For a description of the regional geological setting of Fidalgo Island, read Brown et al. 2007 p. 143-148, which is appended to this field guide. The briefest summary of Brown et al. (2007) is that the San Juan Islands are underlain by Paleozoic and Mesozoic oceanic rocks stacked in several southeasterly dipping nappes, or thrust sheets. The age of these and other thrusts in the northwestern Cascade Range are bracketed between about 115 and 85 Ma.

Fidalgo Island is in the uppermost of the San Juan thrust sheets, the Decatur terrane (Brandon et al., 1988). The Decatur terrane consists of the predominantly plutonic and volcanic Fidalgo complex, which appears to be mostly middle to upper Jurassic, and an overlying uppermost Jurassic to lower Cretaceous clastic succession, the Lummi Formation (Brandon et al., 1988, fig. 21). According to Brown et al. (2007, fig. 22), the Fidalgo Complex consists of, from the base upward, ultramafic rocks, layered gabbro, unlayered gabbro, and unconformably overlying dacitic to andesitic rocks, tuffaceous argillites, coarse fragmental rocks, and rocks of the Lummi Formation. The Lummi Formation is about 2 km thick and consists of lithic sandstone, mudstone, and conglomerate (Brandon et al, 1988).

Cheney (1987, figs 2 and 5)) inferred that the southeasterly dipping thrust sheets of the San Juan Islands are dextrally offset about 50 km from similar but southwesterly dipping rocks in the western foothills of the Cascade Range by what he named the northwesterly trending Mount Vernon fault. The potentially correlative units of the San Juan Islands in the western foothills are the Eastern and Western mélange belts of Paleozoic and Mesozoic rocks, respectively



DESCRIPTION OF MAP UNITS ON FIDALGO ISLAND
(mostly sumarized from Whetten et al., 1988)
Qun – unconsolidated sediments less than 30 m thick
Quk – unconsolidated sediments more than 30 m thick
--- unconformity ---
LOPEZ TERRANE (Late Cretaceous)
Kls – foliated greywacke-argillite flysch with minor chert, greenstone, and conglomerate

FIDALGO COMPLEX OF THE DECATUR TERRANE (Late and Middle Jurassic)
Jfs – sandstone composed of angular clasts of volcanic rocks and euhedral plagioclase in argillaceous matrix; age 148 Ma; a.k.a. Lummi Formation
--- unconformity ---
Jfa – black argillite, locally with fine-granied sandstone
Jfb – unsorted and unbedded fragmental rocks composed of volcanic and/or plutonic clasts in red or green argillaceous matrix; clasts commonly felsic and up to 50 cm in diameter
Jfk – altered flows and flow breccia, locally quartzose
--- unconformity ---
Jfi -- trondjhemite to gabbro
Jfl – layered gabbro; age 167 + 5 Ma
Jfsp – serpentinite
Jfu – Fidalgo Complex undivided

Figure 1. *Geologic map of Fidalgo Island (from Whetten et al. 1988). Numbered circles are field trip stops. For scale, the squares on the map are one mile on a side.*

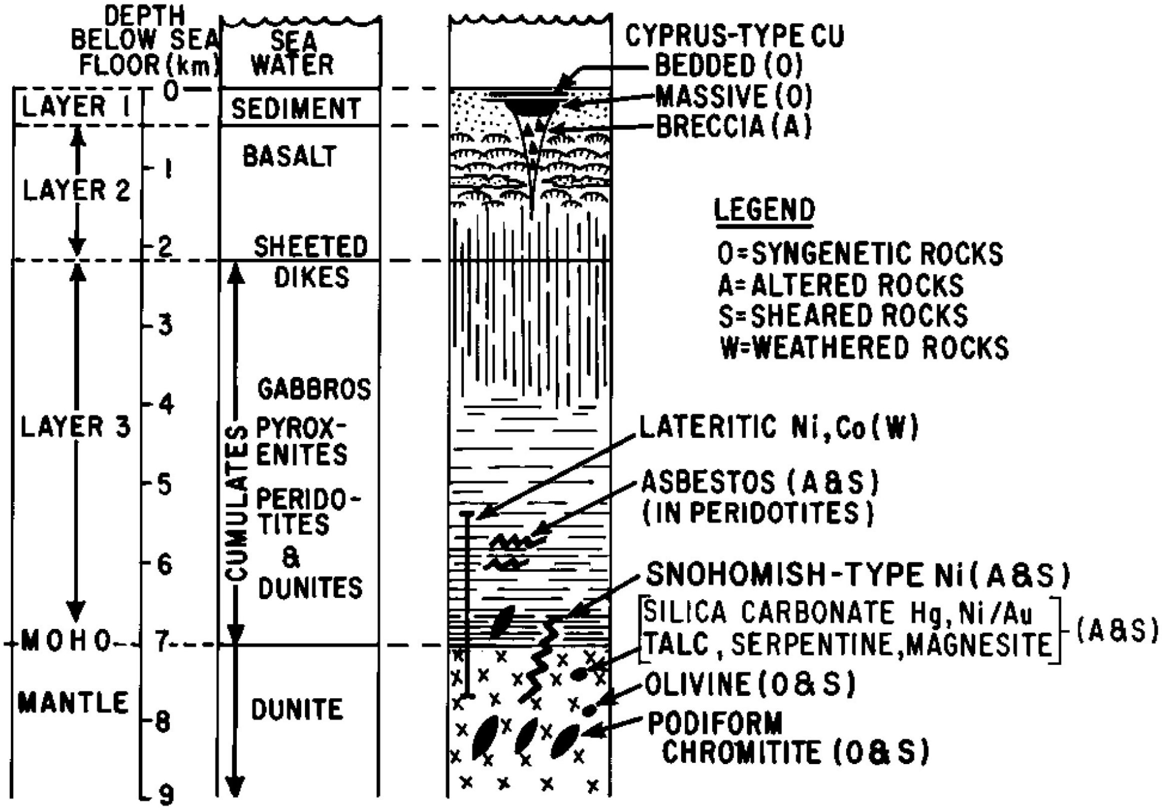


Figure. 2. *Schematic diagram of an ophiolite complex and its mineral deposits. Note that the complex is not restricted to ultramafic rocks; instead, it extends from the upper mantle to the sea floor. Because ophiolites are tectonically emplaced, completely intact complexes are unusual; more commonly, complexes are top-less, bottom-less, or both. Sub-Moho rocks are foliated. The zone of sheeted dikes consists of numerous basaltic dikes that commonly intrude one another, so that "half-dikes" are common. The symbols above the sheeted dikes depict pillow lavas. In the legend for ore deposits, "syngenetic" means that the deposit formed at the same time as the enclosing rocks.*

The sheeted dikes show that ophiolites form in extensional environments. However, the subsequent tectonic emplacement of ophiolites and associated rocks commonly is compressional or transpressional. Ophiolites can be unconformably overlain, intruded, or tectonically interleaved with originally unrelated rocks. To be part of the same complex, all rocks should be approximately the same age`.

(see Brown et al. 2007, fig 2). The inferred Mount Vernon fault (which was not shown by Brown et al. 2007, fig. 2) also offsets Eocene and Miocene strata (Cheney, 1987, fig 2). As is apparent from Brown et al. (2007, fig. 2), the tectonic model of Cheney (1987) has gained virtually no traction.

III. ROAD GUIDE

From Seattle, drive northbound on I-90 to Exit #230 and turn westward on SR 20 toward Anacortes.

Continue westward on SR 20 for 11.7 miles to MP 47.9, which is the junction of SR 20 and SR 20 Spur.

Turn left on SR 20 toward Oak Harbor and Port Townsend.

Proceed 0.1 miles on SR 20 and turn right into the parking lot of The Corner Restaurant, which is a convenient toilet and coffee stop, as well as the first field stop.

Stop 1: Coarse fragmental rocks, The Corner Restaurant
In the garden of The Corner Restaurant are blocks of an unbedded, unstratified, fragmental rock with light colored, angular clasts in a dark matrix. The source of these blocks is almost certainly Stop 7, the quarry of Lakeside Industries.

Continue westbound on SR 20 to MP 46.8 at a long road cut at the crest of a hill.

Park on the wide right shoulder just past the road cut.. Examine the better-exposed road cut on this side of the highway.

Stop 2: Ultramafic rocks, gabbros, and granitic rocks, SR 20
These rocks are representative of one of the most widespread suites on the island. They consist of variably serpentinized ultramafic rocks, gabbros of various grain sizes, and minor granitic rocks (a.k.a.“plagiogranites”). All are extensively fractured. Although some of the contacts are faulted, intrusive contacts (and, perhaps, the density of veinlets of various sorts) indicate the relative ages of the three types of rocks. The ultramafic rocks are intruded by gabbros, which, in turn are intruded by the plagiogranites.

Continue westbound on SR 20 to MP 42.1, the island between the bridges at Deception Pass. In the event of heavy traffic, park near the northern abutment of the bridge.

Stop 3: Lummi Formation at Deception Pass, Deception Pass State Park, SR 20
This is a difficult rock to identify. In heavy rain, while in a dark forest, especially with a fogged-up hand lens, this rock can look like quartz diorite. This is especially true in the dank forest in the Western mélange belt near Spada reservoir. However, here, in the parking lot at the memorial plaque look for tell-tale lithic fragments in otherwise unsorted and unstratified rock. This rock is quite similar to the Lummi Formation at Cap Sante (Stop 11), but here the rock has a much less intense planar fabric (foliation).

Depending upon the tidal cycle, currents though Deception Pass can be impressive and dangerous for some boats.

Read the plaque commemorating Capt. George Vancouver and Master Joseph Whidbey.
Vancouver’s ship was the first to explore Puget Sound. Note the date and contemplate the changes that white humans have wrought in so little time.

Return eastbound on SR 20 to MP 42.8 and turn left (northbound) on Rosario Road. Proceed 0.8 miles on Rosario Road and turn left (west) down Cougar Gap Road.

Proceed 0.1 miles and turn left (south) toward the Marine Station of Walla Walla University.

Proceed 0.3 miles to the end of the road in Deception Pass State Park.

Take the trail across the meadow to the hill (peninsula) beyond. Where the trail forks just beyond the Maid of Deception Pass, stay left (south) and climb to the top of the hill.

Stop 4: Basalt, ribbon chert, and argillite, Rosario Head, Deception Pass State Park
The top the hill is capped by basalt. Descend the northern side of the hill into intercalated ribbon chert and basalt, below which (near the highest tide line) is black argillite. Folds in the ribbon chert are particularly photogenic. The chert contains Late Jurassic radiolarians (Whetten et. al., 1988). Radiolarian chert typically is a deep-water sediment (far from land).

These are rocks of the Lopez terrane (Gusey and Brown, 1987; Whetten et al., 1988) in the thrust sheet below the Decatur terrane. Thus, the Lopez thrust, the lower bounding thrust of the Decatur terrane, is beneath the tombolo that connects this hill to the mainland.

Return to Rosario Road and turn left (northbound).

Proceed 2.6 miles on Rosario Road to the junction with Marine Drive.

At this junction, stay right on Rosario Road and proceed 1.0 miles to the junction with Heart Lake Road.

Turn left (northbound) on Heart Lake Road and proceed 1.3 miles to Ray Ault Road, which has a sign for the Mount Erie Viewpoint.

Proceed 0.1 miles and turn right on Mount Erie Mountain Drive.

Drive 1.6 miles to the summit of Mount Erie

Stop 5: Mount Erie Summit, Anacortes City Park
See the description of these rocks in Brown et al. (2007, Stop 3-4).

Enjoy the view from the summit (to the west of parking lot). The gabbros here are as veined and texturally varied as those at Stop 2. Look for mafic/ultramafic xenoliths.

Another important feature to note, which is not evident at Stop 2, is that where not covered by lichens, the gabbros, especially the more feldspathic ones, are quite white weathering. Thus, they appear to be quite felsic, but quartz is not megacopically visible. This felsic appearance probably explains why some authors have called these and similar gabbros plagiogranites.

Brown et al. (2007) called the gabbroic rocks diorites and assigned them to the sheeted zone of an ophiolite (compare with Fig.2).

Return to the parking lot and take the walkway at the south end of the lot. Enjoy the view of the Cascade Range from the end of the walkway. On a clear day Mount Baker volcano is visible between (but beyond) the oil refineries in the foreground. In front of Mount Baker is the dark colored

Twin Sisters Range, which is underlain by the Twin Sisters Dunite; this ophiolite is a northwesterly striking slab about 19 km long to the northwest, 6 km wide, and 1 km thick.

Return downhill on Erie Mountain Drive to Ray Ault Road.

Turn around and drive back up Mount Erie Mountain Drive 0.2 miles to a pull-out on the right.

Stop 6: Metadacite and Mn-rich strata, Mt. Erie Mountain Drive

Read the description of the manganiferous argillite and the dacite in Brown et al. (2007, Stop 3-3). We will discuss these rocks again at Stop 7.

Return to Heart Lake Road and turn left (southbound) to Rosario Road.

Turn right on Rosario Road and proceed 1.0 mile to the junction with Marine Drive.

Turn right (northbound) on Marine Drive and proceed 0.9 miles to the junction with Havecost Road. Continue straight ahead on Havecost Road.

Proceed 0.9 miles to the driveway on the right to the quarry of Lakeside Industries.

Stop 7: Relationships of various lithologies, Quarry of Lakeside Industries

See the description of Brown et al. (2007, Stop3-5).

We do not have time to enter the quarry. The purpose of this stop is to very briefly inspect the boulders along the driveway.

According to Brown (1977) and Brown et al. (2007), the working face of the quarry, the southwestern wall, is composed of plagiogranite. Inspection of the quarry in 2011 showed that, instead, it is mostly composed of the same suite of rocks as at Stop 2. The northeastern side of the quarry is underlain by overburden and a chloritic managaniferous argillite (Brown, 1977; Brown et al, 2007) similar that at Stop 6. Although most of the argillite in the quarry appears to be massive or weakly bedded (in beds greater than centimeters thick), some is well laminated.

The lithology to especially note in the boulders along the driveway is a coarse fragmental rock (a.k.a. "sedimentary breccia") that is unsorted and unstratified. According to Brown et al. (2007) elsewhere in the quarry it contains clasts of all of the plutonic lithologies, including ultramafic rocks. Most noticeably, the rock also contains clasts of light-colored aphanitic rock (a.k.a. " keratophyre") (Brown, 1977, similar to the metadacite at Stop 6. It also contains clasts of fine-grained, quartz-bearing, felsic rocks.

The coarse fragmental rocks may represent a landslide or talus (Brown et al, 2006), perhaps induced by faulting. The manganiferous argillite is a deep marine (abyssal) sediment (Brown, 1977). Alternatively, perhaps, both the coarse fragmental rock and the manganiferous argillite were derived from a local vent, like similar rocks in volcanogenic massive sulfide deposits (and similar to the Cyprus-type copper-zinc deposit shown in Fig. 2). Because felsic volcanic rocks, such as dacites, are extremely rare along mid-oceanic rifts, these rocks may have accumulated in or adjacent to an island arc.

According to maps of the quarry by Gusey (Brown, 1977; Gusey and Brown, 1987) the coarse fragmental rock strikes northwesterly and unconformably overlies the suite of plutonic rocks (Fig. 1). The coarse fragmental rock, is, in turn, overlain by the black, manganiferous argillite and by greywackes.

Return 0.9 miles to the junction with Marine Drive.

Turn right (west, but northbound) on Marine Drive.

Proceed 1.2 miles to Marine Lane on the left (west) and marked by 5 mail boxes beneath a green roof. Park near the mail boxes.

Walk 0.1 miles up Marine Lane almost to the driveway of house # 11310.

Stop 8: Layered Gabbro, Marine Lane
Although the outcrop is rather intensely veined, note (1) the graded beds (marked by the decreasing abundance of mafic minerals upward) in the gabbro and (2) that the beds face northeastward. On the south side of the outcrop (in the adjacent driveway) is an unveined, microgabbroic (basaltic) dike.

Layered mafic rocks occur in several geologic environments. How can we be reasonably sure that this example is part of an ophiolite complex?

Whatever the origin of the layered gabbro, it is a middle to upper crustal lithology. The rocks underlying the islands on the west side of Burrows Bay to the west are upper mantle ultramafic rocks similar to those at Stops 9 and 10. Contemplate the type and orientation of the structure under Burrows Bay that juxtaposes these two contrasting lithologies.

Return to Marine Drive and continue northbound.

Proceed 0.5 miles to Marine Heights, where Marine Drive becomes Anaco Beach Road. This is the site of Stop 3-2 of Brown et al. (2007).

Continue another 1.4 miles northbound on Anaco Beach Road to the junction with Sunset Avenue.

Turn left (west) on Sunset Avenue and proceed 0.6 miles to the entrance of Washington Park.

Proceed 0.7 miles westward from the entrance of Washington Park on the Loop Road to a large parking area on the left.

Walk across the road and descend the concrete steps to look at outcrops within 30 m to the northwest. The rocks here can only be extensively viewed at low tide.

Stop 9: Ultramafic rocks, Washington Park
See the description of Brown et al. (2007, Stop 3-1).

From the bottom of the concrete steps, observe that in the sea cliffs the thickness of the overburden on the glacially polished ultramafic rocks is as much as 5 m thick.

The ultramafic rocks here are only slightly weathered. Pervasive serpentinite usually is magnetic due to accessory magnetite. These rocks are virtually non-magnetic.

Note three typical weathering characteristics of ultramafic rocks: dun color, "elephant-hide" texture (due to intersecting fractures), and orange lichens.

Compositional layering consists of seemingly fine-grained dunite up to 0.5 m thick in darker colored, coarser-grained peridotite. Note that some of the dunite layers are pulled apart and that some of the peridotite is weakly foliated. Deformational features such as these generally are characteristic of ultramafic rocks derived from the mantle.

Minor seamlets of chromite and monor veinlets of asbestos are reported east of here.

Proceed 2.2 miles on Loop Road to a viewpoint at the top of a hill.

Stop 10: Botany of ultramafic rocks, Washington Park
Notice two botanical characteristics of ultramafic rocks: lack of trees and some orange lichens. Typically, ultramafic rocks are too low in K and Na to support trees. Trees grow in most places in Washington Park because, as at Stop 9, the ultramafic rocks are covered by up to 5 m of glacial sediments (which do contain enough K and Na to support growth).

Madronna trees (the ones with deep red bark) prefer less water than most other species in the Puget Lowland. They grow here because of below average rainfall, and, perhaps, because the glacial overburden is thin.

Proceed 0.6 miles to the exit of Washington Park.

Proceed 3.9 miles straight on Sunset Avenue (and becomes SR 20 Spur) to downtown Anacortes.

Turn left (northbound) on Commercial Avenue and continue 0.5miles to 4th Avenue.

Turn right (eastbound) on 4th Avenue and continue 0.4 miles to V Avenue.

Turn right (southbound) on V Avenue and continue 0.4 miles on V Avenue, 7th Avenue, and W Avenue to the parking lot at Cap Sante

Stop 11: Lummi Formation, Cap Sante
This glacially polished and grooved lithic sandstone is the Lummi Formation of the Decatur terrane (Brandon et al. 1988, fig. 3) and compositionally is like the sandstone at Deception Pass (Stop 2). The lack of visible bedding and a strong planar fabric (striking approximately N330 and dipping 50^{o}SW) make identification of the rock difficult. However, a diligent search will find a few angular lithic fragments.

Note the apparent lack of metamorphic minerals. This suggests that the strong planar fabric is cataclastic, not the normal metamorphic foliation caused by ductile deformation.

A diligent search will also find rare examples of two intersecting planar fabrics that outline lozenges (rather like the ductile S-C fabrics of mylonites). These intersecting fabrics imply strong dextral shear (such as would occur in or adjacent to a major fault zone).

In clear weather, fine views exist of the Cascade Range (to the east), the March Point oil refineries (to the southeast). Mount Erie (Stop 5) is to the south, and the hills of Washington Park (Stop 10) and neighboring islands are to the west.

Because Mt. Erie (Stop 5) is visible to the south, we can contemplate the overall structure of Fidalgo Island by inspecting Figure 1 or Figure 22 of Brown et al. (2007). Judging from (1) the distribution of plutonic *vs*. volcanic and sedimentary rocks, (2) at least some of the strike and dip symbols (including those in the layered gabbro) and

(3) the presence of mostly volcanic and sedimentary rocks northeast and southwest of Mt. Erie, we can speculate that the overall structure of Fidalgo Island is, grossly, a northwest trending antiform. If so, what kind of structure or discontinuity (if any) exists between Cap Sante and Mt. Erie?

Before departing, examine Figure 2 and decide which ophiolitic rocks we did and did not see. Additionally, group each of the rocks that we have seen into appropriate tectonic episodes (see the explanation to Figure 2). Might we consider that the gabbros (and inclusions of ultramafic rocks) simply are basement (of an island arc?) upon which the other rocks were deposited)?

Return to Commercial Avenue and turn left (southbound)

Follow Commercial Avenue 0.5 miles southward where it joins SR 20 Spur.

Follow SR 20 Spur 4.1 miles southbound to the junction with SR 20.

Continue straight on SR 20 to I-5 and turn southbound to Seattle.

IV. ACKNOWLEDGEMENTS

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