CHAPTER 5
The Physical Setting of Shemya Island

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Location and Access

Shemya Island (52°43' N, 174°07' E) is in the Near Islands at the western end of the Aleutian Islands, approximately 1,600 km west of Anchorage, Alaska. The Near Islands comprise Attu Island, Agattu Island, and the Semichi Islands, including Nizki Island, Alaid Island, and Shemya Island (Figure 5-1).

Shemya and Attu can be reached by aircraft, but the rest of the Near Islands can only be accessed by boat or amphibious airplane. Although Barneckson Air Force Station, on Shemya Island, was closed in 1995, the 10,000 foot runway continues to support defense-related activities. A 6,500 foot runway on Attu supports the 20 person U.S. Coast Guard crew maintaining a Loran navigation beacon. Access to Shemya is restricted and requires Air Force permission; Attu is likewise limited to military support flights.

Physiography and Bathymetry

Attu is the largest of the Near Islands, with an area of 906 km². The island is covered by rugged mountains approaching elevations of 1,000 m, cut by broad U-shaped glacial valleys.

Figure 5-1: The Near Islands.
Agattu encompasses some 225 km$^2$ of rolling hills and terraces less than 300 m in elevation and a low mountain range along the north coast that reaches 600 m above sea level.

The Semichis Island group extends from Alaid—located 30 km east of Attu—22 km east-southeast across Nizki, to the eastern end of Shemya Island. Nizki is low and flat with a maximum elevation of 50 m; hills on Alaid are as high as 180 m. Nizki and Alaid Islands are joined by a sandbar as wide as 50 m, which is exposed at low tide.

Shemya is a flat-topped seamount approximately 2.7 km wide and 7.1 km long on a west-east axis; it has an area of 1,425 ha and a shoreline of 22 km. At 14 km$^2$, Shemya encompasses half the land area of the Semichis. The island slopes gently south from 73 m high sea cliffs overlooking the Bering Sea coast to bluffs between 6 m and 8 m high delineating the rocky south shore of the Pacific Ocean. The inclined planar topography of Shemya suggests a tilted wavecut platform. The rugged shoreline is broken only by small, sandy or gravelly beaches.

The Aleutian Islands mark the top of a broad submarine ridge stretching more than 3,000 km west from the tip of the Alaska Peninsula to the Kamchatka Peninsula; this ridge divides the Pacific Ocean from the Bering Sea. North of this Aleutian Ridge (and islands), the Bering Sea reaches depths of more than 4,000 m in the Aleutian Basin; to the south, the Aleutian trench locally exceeds 8,000 m in depth, more than 2,000 m deeper than the floor of the Pacific Ocean.

The abyssal depths of the Bering Sea are bounded by the continental shelf at 200 m below sea level (Figure 5-2). The 500 km to 600 km wide Bering shelf arcs northwest from the tip of the Alaska Peninsula to Cape Navarin on the Koryak Peninsula and extends some 50 km southwest of St. George Island and 250 km southwest of St. Matthew Island (Scholl et al. 1975).

The Aleutian Basin underlies the Bering Sea southwest of this shelf except in the south-western quadrant where Komandorsky Basin and Bowers Basin are isolated by the Shishshov and Bowers submarine ridges. Bowers Ridge sinuously arcs over 600 km north and west from Semisopochnoi Island in the Rat Islands. Shishshov Ridge curves 600 km south from Cape Oliyutorsky in Russia to near the northern slope of the Aleutian Ridge, midway between the Near Islands and Komandorsky Islands.

Shemya occupies the northeast corner of the Near Island Shelf, a west-pointing triangular submarine plateau 80 km wide by 160 km long straddling the Aleutian Ridge at 180 m below sea level (Figure 5-1). Attu and Agattu are, respectively, located near the western and southern edges of the shelf. Deep, steep-walled submarine passes or canyons isolate the Near Islands from other islands and island groups and help define their distinctive oceanography and climate (Loughlin and Ohtani 1999; Stabenow et al. 1999).

Oceanography

The circulation in the Bering Sea is described as a cyclonic gyre, with the south-flowing Kamchatka Current forming the western boundary and the northward flowing Bering Slope Current forming the eastern boundary (Stabenow et al. 1999). The Kamchatka Current originates near 175° E (Shishshov Ridge) and is formed from westward- and northward-flowing water entering the Bering Sea through the Near Strait (Stabenow and Reed 1992). In addition, two well-defined currents affect the near-shore oceanography of the Near Islands. The Aleutian North Slope current is a weak eastward countercurrent north of the Aleutians (Figure 5-3). Current flow and direction are variable and strongly influenced by local conditions (Stabenow and Reed 1992). The Alaska Stream (Stabenow et al. 1999) is the main source for much of the flow that occurs in the Bering Sea. It begins at the head of the Gulf of Alaska and flows westward along the southern side of the islands at the interface of the Bering Sea and North Pacific.

The Aleutian Ridge is a porous boundary, intersected by 14 major passes, between the Bering Sea and the North Pacific. The passes play a primary role in determining both circula-
with the south-flowing Bering Slope Current. The Bering Slope Current originates from the southward-flowing water masses (Sverdrup 1942). In addition, two other systems influence the region. The Aleutian Islands and the Aleutian Front interact with the Aleutian Islands and the Aleutian Front. The Aleutian Islands and the Aleutian Front are the source of much of the water that flows into the Bering Sea and northward into the Pacific Ocean. This interaction occurs between the Japan and Aleutian Trenches, where the Aleutian Trench and the Aleutian Islands converge. The Aleutian Trench is a major geophysical feature that affects the circulation of water in this region. The Aleutian Trench creates a barrier that diverts water away from the Aleutian Islands and into the Bering Sea. This interaction between the Aleutian Islands, the Aleutian Front, and the Aleutian Trench is crucial for understanding the circulation and dynamics of the region.
Figure 5-3: North Pacific and Bering Sea current system (McAllister and Favorite 1977, p. 332).
tion and distribution of water properties (Loughlin and Ohtani 1999; N slewbauer et al. 1999; Reed and Stabenow 1999; Stabenow et al. 1999). For the Near Islands, the Near Strait and Buldir Pass are the most significant. Near Strait is one of the deepest passes in the chain and separates the Near Islands from the Commander Islands (Figure 5-2). Most of the transport into the Bering Sea occurs through Near Strait (6–12 x 10⁶ m³/s). Recent research indicates that the flow through the pass is extremely variable (Stabenow et al. 1999; Figure 5-3). Occasional eddies in the Alaska Stream inhibit flow into the Bering Sea through Near Strait.

Tides enter the Bering Sea from the Pacific Ocean, and tidal currents play a vital role in the physical oceanography over the Near Island shelf (Table 5-1; Kowalik 1999). They provide sufficient energy to mix the top 40 m of water.

This sets up a two-layer density structure in water depths of 50 to 100 m. Shallower than this, the water column is weakly stratified or well-mixed (Schumacher and Stabenow 1998). Tidal currents may contribute to the cross-shelf flux of salt, nutrients, and heat necessary to maintain the high levels of primary production over the shelves.

Climate

The Near Islands are located in the extreme southwestern corner of the Bering Sea and are strongly influenced by Bering and North Pacific oceanography. Large-scale weather patterns in both the tropical South Pacific (El Niño–Southern Oscillation events) and the North Pacific (Pacific–North America pattern) have strong connections to the Bering Sea, mainly via the atmosphere (Niewauer et al. 1999). Aleutian climate is dominated by the Aleutian Low, one of the two main low-pressure systems in the high-latitude northern hemisphere (Niewauer et al. 1999; Overland 1981; Overland and Pease 1982; Stabenow and Reed 1992). During summer, with its long periods of daylight and high insolation, the Aleutian Low is typically weak, and the weather is benign. During winter, high sea-level pressure (Siberian High) dominates Asia, and the Aleutian Low intensifies and dominates weather over the North Pacific and Bering Sea. The frequency and intensity of storms in the southern Bering Sea increase in winter (Overland 1981; Overland and Pease 1982). An average of three to five storms per month move eastward along the Aleutian Chain forming the primary storm track in the North Pacific and Bering Sea.

The weather is typical of a northern maritime climate, with moderate year-round temperatures and strong winds (Sekora 1973). Warm, moist air from the Pacific Ocean colliding with cold Arctic air forms nearly continuous fogs, cloud cover, and high wind. Over 50 years, the annualized minimum temperature was 2.1°C, the maximum was 5.2°C, and the mean annual temperature was 3.8°C (Figure 5-4). Temperatures range from -2°C to 13°C, with average monthly temperatures varying between -1°C and 10°C (Figure 5-5). The warmest months are August and September; the coldest are January and February. Snow accumulation varies, but rarely exceeds 60 cm. Annual precipitation on Shemya is 457 mm; December and January are

| Table 5-1: Near Island tidal ranges measured from mean low water. |
|-----------------|-----------|-------------|-------------|
| Island          | Location  | Highest Tide| Mean High Tide| Lowest Tide |
| Attu            | Chichagof Harbor | 1.13 m      | 0.55 m       | -0.91 m     |
| Stellar Cove    | 1.13 m    | 0.55 m       | -0.91 m     |
| Etinene Bay     | 1.13 m    | 0.55 m       | -0.91 m     |
| Massacre Bay    | 1.01 m    | 0.49 m       | -0.91 m     |
| Shemya          | Acan Harbor | 1.04 m      | 0.52 m       | -1.07 m   |
| Agattu          | McDonald Cove | 1.04 m      | 0.52 m       | -0.91 m   |

1. From NOAA navigation charts
the wettest, and September and October are the driest months.

Mean monthly wind speeds are nearly constant throughout the year, varying from about 8 m/s in June and July to 10 m/s in December and January (Figure 5-6). Peak wind speeds are much more variable, with mean monthly maximums of about 30 m/s (60 kt) in June to more than 55 m/s peaks in December. Aleutian winds are legendary. Beaudet (1960:19) reports, “Hurricane velocities (75 mph) occur on all of the islands from 10 to 15 times a year.” In addition, katabatic winds, called williwaws, build up on windward mountain slopes, then pour down the leeward slopes with hurricane force (Beaudet 1960; NOAA 1987).
Geology

Previous Investigations

Little geological fieldwork has been completed on Shemya Island. The U.S. Geological Survey conducted a reconnaissance of Shemya during the summers of 1949 and 1950 as part of the Alaska Volcano Project (Gates et al. 1971; Schafer 1971). This military-funded work was prompted by the eruption of Okmok Volcano on Unimak Island in 1945 and was directed toward identification of geological hazards that might affect military operations. Additional Near Island geological data were included in an engineering intelligence study prepared for the Army in 1952 (USGS 1960). Cameron and Stone (1970) collected palaeomagnetic and potassium-argon age-dating samples from Shemya in 1967 while conducting pioneering research into the role of island arcs in the emerging theory of plate tectonics.

Tectonic Setting

The Aleutian arc is a seismically and volcanically active ridge-trench geomorphic system (Figure 1-1 and 5-2). A belt of 89 Quaternary volcanoes, half of which have been historically active, stretches 2,500 km from Mt. Hayes in the Alaska Range southwest along the Alaska Peninsula and Aleutian Chain (Moryka et al. 1993). Volcanic activity is fed by partial melting of Pacific plate rocks subducted to depths of more than 110 km (Spence 1977). Buldir Island, some 115 km east of Shemya, marks the western limit of recent volcanic activity, and the nearest historically active volcano is on Kiska Island, 275 km east of Shemya (Miller et al. 1998).

The eastern portion of the arc extending down the Alaska Peninsula to Unimak Pass marks the subduction of the Pacific plate beneath continental rocks of the North American plate at a rate of 6.4 to 7.1 cm/year (Fournelle et al. 1994; Marlow et al. 1973). The oceanic crust is mantled by sediments shed by the erosion of North America. Because of the curvature of the earth, the movement of the Pacific plate, which is almost perpendicular to the arc near the Alaska Peninsula, gradually becomes nearly parallel to the arc in the Near Islands. Plate
convergence steadily decreases west of Unimak Pass, with a corresponding reduction in subduction and volcanism. Oceanic rocks of the Pacific plate in this sector lack the thick mantle of North American sediments, and the Pacific plate is subducted beneath oceanic crust. Further west, the Komandorsky–Near Island sector of the ridge is essentially a right-lateral strike-slip fault zone between oceanic plates. The Aleutian Trench west of the Near Islands is a relic from some 50 million years ago (Ma) when the Pacific plate moved in a more northerly direction and was subducted along this segment of the arc (Taber et al. 1991:29). The arc terminates in the west where the Pacific plate is thrust beneath the Sea of Okhotsk plate, forming the Kurile Trench and Kamchatka Peninsula (Moore et al. 1990).

The central and western Aleutian volcanic arc is segmented into five discrete blocks corresponding to the Near, Buldir, Delarof, Rat, and Andreanof island groups (Spence 1977). Blocks are bounded by north-trending, steep-walled submarine canyons corresponding to high-angle faults and by arc-parallel strike-slip faults that coalesce west of the Near Islands. Because the Pacific plate moves at an acute angle to the arc, part of the movement is directed downward into the subduction zone, and part is directed along the arc. The differential between these two components of Pacific plate motion—arc-parallel strike-slip and convergent underthrusting—is partially accommodated by rotation of the fault-bounded island blocks. The presence of triangular summit basins along the ridge suggests that grabens—down-dropped fault blocks—occur in extensional zones at the intersection of the strike-slip and high-angle faults (Geist et al. 1988).

The Aleutian arc did not exist prior to the Eocene, some 55 million years ago; it was preceded by the Beringian margin, an active arc-trench complex located along the southwest edge of the Bering Shelf. Late Cretaceous and Paleocene (74–55 Ma) volcanic and plutonic rocks were emplaced along a broad belt sweeping northwest from the Alaska Peninsula to the Koryak Peninsula following docking of the Talkeetna Superterranne, which underlies most of southcentral Alaska. Subduction along the Beringian margin abruptly stopped when a north-facing arc-trench, the Olyutorsky-Bowers complex, collided with and obducted the Koryak side of the Beringian margin in late Paleocene time (56 Ma) (Worrall 1991). With the Beringian trench jammed, the Kula plate buckled some 500 km south of the old Beringian margin, creating the Aleutian arc and stranding oceanic crust to the north (Geist et al. 1988).

The Aleutian arc grew rapidly, with magma generated by subduction of the Kula plate at a rate of 20 cm/yr, from 55 Ma to about 43 Ma. The bulk of the arc was constructed by middle Eocene (43 Ma), when volcanic activity diminished with decreased subduction rates of 5.8 to 7.0 cm/yr. This is attributed to more oblique plate convergence, as indicated by the bend in the Emperor-Hawaiian seamount chain and concurrent abandonment of the Kula-Pacific spreading center (Geist et al. 1988).

Volcanism gave way to the intrusion of plutons that uplifted and folded the ridge crest during the Oligocene and Miocene (37–5.3 Ma). Large volumes of conglomerate, graywacke, argillite, chert, siliceous shale, diatomaceous siltstone, and volcaniclastic sediments were deposited in basins between volcanic centers and on the ridge flanks (Scholl et al. 1975). Pacific plate motion shifted to a more northerly, convergent direction at the start of the Pliocene (5.3 Ma), resulting in a substantial increase in volcanic activity, which continues today (Geist et al. 1988).

**Geologic Hazards**

Shemya Island is within seismic zone 4, which reflects the highest hazard potential for earthquakes and severe ground shaking (Sekora 1973). Approximately 7 percent of the annual worldwide release of seismic energy occurs in the Aleutian arc (Dillon 1977; Sykes 1971). Earthquake magnitude is presented in terms of moment magnitude ($M_w$), a logarithmic
scale that has supplanted the Richter scale. More than 70 large earthquakes having moment magnitudes ($M_w$) of at least 7.0 occurred along the arc during the 20th century (Rowe 1994). Selected large earthquakes are presented in Table 5-2, which ranks three Aleutian earthquakes in the 10 largest recorded since 1904.

The coastlines are susceptible to tsunamis (tidal waves) resulting from ocean floor displacements and earthquake-triggered submarine landslides (Schumacher and Stabenow 1998). There is no record of destructive tsunami activity on the Bering Sea coast of the Aleutians; the danger originates from the Pacific Ocean. The average runup height of 25 tsunamis recorded between 1944 and 1973 was 0.5 m, with maximums ranging from 0.1 m to 3.2 m at Massacre Bay and from 0.1 to 10.7 m on Shemya (Cox and Pararas-Carayannis 1976).

The 1965 Rat Island earthquake fractured a runway on Shemya, and the resulting 10.7 m tsunami inundated the south coast, covering part of the runway. In the past, large earthquakes may have damaged villages located along the base of cliffs lining the north coast of Shemya, and tsunamis would certainly have devastated low-lying villages along the south coast.

**Stratigraphy**

Attempts to define regional stratigraphic sequences in the Western Aleutians are hampered by rapid facies changes, lack of distinctive fossils, extensive thermal metamorphism, and structurally obscured contact relationships. Aleutian stratigraphy is divided into three chronostratigraphic units designated Lower Series, Middle Series, and Upper Series, which reflect the three phases of Aleutian Arc development (Vallier et al. 1994). Chronostratigraphic units combine all contemporaneous units, including volcanic, intrusive, and sedimentary rocks.

The Lower Series (LS) comprises Eocene (55–37 Ma) rocks, including the Kuglof, Chirikof, and Nevidiskov Formations, and undifferentiated basement rocks of the Near Islands. (Basement rocks are very old granite and metamorphic rocks found in continental crust.)

<table>
<thead>
<tr>
<th>World Rank</th>
<th>Date</th>
<th>Moment Magnitude ($M_w$)</th>
<th>Epicenter</th>
<th>Tsunami Location</th>
<th>Runup (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>Mar. 28, 1964</td>
<td>9.2&lt;sup&gt;1&lt;/sup&gt;</td>
<td>Prince William Sound</td>
<td>Attu, Massacre Bay</td>
<td>0.4&lt;sup&gt;2&lt;/sup&gt; 0.18&lt;sup&gt;3&lt;/sup&gt;</td>
</tr>
<tr>
<td>3</td>
<td>Mar. 9, 1957</td>
<td>9.1&lt;sup&gt;1&lt;/sup&gt;</td>
<td>Andreanof Islands (near 1986 epicenter)</td>
<td>Adak, Sweeper Cove</td>
<td>4.0&lt;sup&gt;4&lt;/sup&gt; 9.1&lt;sup&gt;1&lt;/sup&gt; 0.6&lt;sup&gt;5&lt;/sup&gt;</td>
</tr>
<tr>
<td>6</td>
<td>Feb. 4, 1965</td>
<td>8.7&lt;sup&gt;1&lt;/sup&gt;</td>
<td>Rat Islands</td>
<td>Adak</td>
<td>4.2&lt;sup&gt;6&lt;/sup&gt; 2.9&lt;sup&gt;7&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td>Apr. 1, 1946</td>
<td>8.3&lt;sup&gt;1&lt;/sup&gt;</td>
<td>Unimak Island</td>
<td>Unimak Island–Scotch Cap</td>
<td>&gt;30.0&lt;sup&gt;8&lt;/sup&gt; 0.2&lt;sup&gt;4&lt;/sup&gt;</td>
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<tr>
<td></td>
<td>Nov. 10, 1938</td>
<td>8.2&lt;sup&gt;1&lt;/sup&gt;</td>
<td>Alaska Peninsula</td>
<td>Dutch Harbor</td>
<td>0.1&lt;sup&gt;2&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td>May 7, 1986</td>
<td>7.9&lt;sup&gt;1&lt;/sup&gt;</td>
<td>Andreanof Islands (near 1957 epicenter)</td>
<td>Adak</td>
<td>1.7&lt;sup&gt;9&lt;/sup&gt;</td>
</tr>
</tbody>
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*Approximately 7 percent of the earth's crust is the Aleutian arc (Dillon 1977; Sykes 1983). The magnitude ($M_w$) of an earthquake on a logarithmic scale.(*)
rocks make up the continental shield. LS rocks record the construction of the Aleutian Ridge and show diminishing intrusive activity at the close of the Eocene. LS rocks have been subject to numerous intrusive events and are commonly metamorphosed to lower greenschist-facies mineral assemblages, particularly near plutons. Penetrative deformation fabrics are locally developed in metaplutonic rocks near faults, resulting in blocks of actinolite-plagioclase-quartz schist, amphibolite, and mylonite. Age dates of LS rocks reflect metamorphism rather than primary crystallization.

LS rocks in the Near Islands include basaltic to rhyolitic volcanic and volcanoclastic rocks, limestone, chert, and hypabyssal dikes and plugs of gabbro, diorite, diabase, and basalt. The Kruglof Formation on Agattu Island and the Nevidiskov Formation on Atu are probably correlative, consisting of a well-bedded sandstone, argillite, and limestone. On Shemya, LS rocks are represented by the basement rocks, a heterogeneous sequence of interbedded, pyritic basalt, tuff breccias, argillite, siltstone, shale and graywacke underlying the western half of the island (Gates et al. 1971).

The Middle Series (MS) includes all Oligocene and Miocene age (37–5.3 Ma) rocks. On Atu, this includes fine-grained, siliceous sedimentary rocks of the Miocene Chuniksak Formation and Massacre Bay Formation comprising andesitic and dacitic lavas plus associated volcanoclastic rocks and hypabyssal intrusive rocks. MS strata form extensive, uniformly thick blankets mantling the fore-arc and back-arc slopes of the ridge, unconformably overlying LS strata (Vallier et al. 1994). Two periods of MS intrusive activity are identified in the Near Islands. Hypabyssal plutons of gabbro, diorite, and quartz diorite were emplaced on Atu and Agattu 34–28 Ma, and younger dikes and plugs of porphyritic andesite and dacite were emplaced on Shemya and the north coast of Agattu 15–11 Ma (Vallier et al. 1994).

The Upper Series (US) comprises Pliocene and Quaternary rocks (younger than 5.3 Ma), including thick deposits of conglomerate, graywacke, and argillite making up the Faneto Formation on Atu and the Kiska Harbor Formation on Kiska Island, 220 km east of Shemya (Panuska 1980). These fluvial-like deposits record rapid infilling of grabens (down-dropped fault blocks) along the Near Island–Amchitka Lineament. US rocks also include a really extensive, epiclastic marine flysch deposit mantling the submerged Near Island shelf and flanks of the Aleutian Ridge. No US rocks are recognized on Shemya Island.

**Bedrock Geology**

Bedrock geology was compiled from Gates and colleagues (1971), modified in accordance with Cameron and Stone (1970), and recently declassified data presented by the U.S. Geological Survey (1960). The western half of Shemya is underlain by LS rocks consisting of interbedded argillite, tuffaceous sediments, conglomerate with limy nodules, chert, graywacke, and variably altered mafic to intermediate volcanic rocks, termed propylitized andesite (Figure 5-7). Beds dip moderately to steeply north to northwest on the west and southwest coasts. Bedding attitudes vary along the south coast near faults and intrusive contacts.

Structural interpretation is hindered by a paucity of bedrock exposures. North- to north-northeast–striking high-angle faults cut LS rocks south of site ATU-021 and coincide with the contact between LS and MS rocks on the north coast between ATU-021 and ATU-022. A fault extends northwest along the south coast from site ATU-003.

Volcanic and hypabyssal intrusive rocks of the Middle Series (MS) underlie the remainder of the island. The center of the island is occupied by an approximately 1 km² dacite porphyry stock, dated at 15 Ma ± 3 Ma (Cameron and Stone 1970). A similar, albeit smaller, plug located 1 km west also cuts LS rocks. This unit was mapped as “feldspar porphyry” and described as a porphyritic andesite or dacite with plagioclase phenocrysts and minor mafic phenocrysts (USGS 1960).
The rocks of the Aleutian Ridge have been subject to lower greenschist-facies metamorphism. Deformation fabrics are locally preserved in actinolite-plagioclase-bearing rocks, indicating metamorphism rather than deformation.

Marine and volcaniclastic sediments, including arkose, diabase, and basalt. Turrits on Attu are probably metasedimentary rocks. On Shemya, LS rocks consist of interbedded, pyritic tuff and mudstone filling the western half of the tuff ring.

Miocene (37–53 Ma) rocks. The Miocene Chuniksak volcanic complex includesdacite lavas plus associated tuffs. Formally overlying LS rocks, it is probably in the near Islands. Rocks on Attu and Agattu have emplaced on older rocks (younger than 53 Ma).

The Funeto (115–120 Ma) east of Shemya is a composite of granodiorite, andesite, dacite, basalt, and pillow lava. Rocks make up the Funeto fault and southwest coasts. Andesite dikes crosscut the Funeto.

Metamorphic rocks. North- to northeast-facing metamorphic rocks coincide with metamorphic rocks on Shemya, 021 and 022. A metamorphic core complex (MCC) underlies the area. Metamorphic rocks are similar, albeit smaller, to "lydian porphyry" and "biotite porphyry" and contain quartz and minor mafic minerals.
Hornblende andesite covers some 2.5 km² at the east end of the island and also occurs as two small plugs intruding LS rocks at the north end of the island and in the west central portion of the island. All reported exposures of contacts with older rocks are faults. This rock was mapped as "hornblende porphyry" and described as a hornblende andesite or dacite (USGS 1960).

Gently northwest-dipping beds of pyroclastic breccia and tuff mantle an area more than 1.5 km², obscuring the contact between dacite porphyry and hornblende andesite. Smaller exposures of pyroclastic rocks as much as several hundred meters in diameter mark the east coast of Shemya. Bedded tuffs and agglomerate are 4 to 37 m thick and include at least two light beds of feldspathic sandstone (USGS 1960).

The pyroclastic beds are cut by two dark-gray equigranular basaltic pipes located on the north and east coasts of Shemya. Columnar jointing is common. A single sample of tholeiitic basalt from the northern pipe yielded an age of 12.3 Ma ± 1.5 Ma, overlapping with the earlier date at the one sigma level (Cameron and Stone 1970).

Tertiary rocks are covered by as much as 16 m of Pleistocene sediments and soils, including sand and gravel beach deposits, peat, and glacial till. Striated bedrock and poorly sorted till-like surficial deposits suggest that a probable Wisconsinan Stage ice sheet covered the Semichi Islands (Schafer 1971).

**Unconsolidated Deposits**

The bedrock surface of Shemya is a wave-cut platform, probably of pre-Wisconsin age (10,000 to 70,000 years BP), which was subsequently tilted to the south (Schafer 1971). The Semichi Islands were probably covered by a single sheet of ice during the late Wisconsin. Streaks on a 1-m² area of glacially eroded bedrock exposed in a quarry indicate that glacial ice advanced from the west (Schafer 1971). The Bering Sea was largely covered by sea ice during both early and late Wisconsin times (Thorson and Hamilton 1986).

U.S. Geological Survey (1960) mapping of unconsolidated deposits was limited to units more than 1.3 m thick for engineering purposes (Figure 5-8). Glacial till—an unstratified, unsorted mix of boulders, cobbles, and gravel in a matrix of sand, silt, and clay—is exposed in shallow excavations on the higher parts of the island. The gray till, as much as 3 m thick, is weathered to a rusty brown in the upper 50 cm, and may be stained black by humic material (USGS 1960). Interbedded sand, gravel, and boulders make up glacial outwash deposits as much as 4 m thick extending northwest from the till (USGS 1960). Outwash gravels underlie peat and sand dunes to the north and wedge out to the south or underlie thick peat deposits (USGS 1960).

As on most Aleutian islands, peat, a partially decayed mat of roots, grass, and moss with variable amounts of clay, silt, and sand, is the dominant surface material on Shemya Island (USGS 1960; Sekora 1973). This water-saturated, partially decayed vegetal mat is generally 1–2 m thick, but is locally several meters thick (Amundsen 1977; Hein 1976; Heusser 1973; Merritt 1977; Schafer 1971). Shemya Island has no permafrost (Kellogg and Nygard 1951; Thomson and Staudt 1993; Ulrich 1946). Raised beach deposits one to two m thick are located 4.7 m above mean high tide on three bays or coves along the north coast (USGS 1960). The raised beaches may have been formed between 2800 and 4000 years BP, when sea levels were elevated 2 to 5 m above present mean high tide (Thorson and Hamilton 1986).

On the north coast of Shemya, the 73 m high sea cliff is capped by eolian silt and sand, locally more than 4.5 m thick. The deposit extends 60 m to 180 m south from the crest of the cliff, thinning inland, and is composed of sand and gravel blown up from the beach by strong onshore winds (Schafer 1971). A similar belt of dunes extends 150 m to 750 m inland from the low south shore of Shemya and covers the low western peninsula (USGS 1960).
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Schafer 1971; Heusser 1973; Egg and Nygard 1951; USGS 1960). The
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Unconsolidated surface materials on Shemya Island include sand, gravel, and peat deposited by marine, alluvial, and colluvial processes. Depth to bedrock varies from zero to more than 8 m. The western one-third of the island and part of the south side of the island are covered by active and stable sand dunes (Gates et al. 1971). The soils of the western Aleutian Islands contain varying mixtures of organic matter and volcanically derived materials (Heusser 1973, 1978, 1990; Schafer 1971; Ulrich 1946). They have counterparts in other cool maritime environments such as Iceland (Johannesson 1960) and Scotland (FitzPatrick 1964). Soil development closely followed recession of the island’s Wisconsin ice cap, approximately 10,500 BP (Gard 1977; Merritt 1977; Thorson and Hamilton 1986).

Hydrology

Shemya Island has a relatively complex hydrogeological environment (Gates et al. 1971; Schafer 1971; Sekora 1973). Both confined and unconfined aquifers occur on the island, with some areas having multiple zones of saturation. Groundwater can be encountered in the surface peat layer that occurs over much of the island, in the unconsolidated sand and gravel that occurs primarily in the southern coastal area, or in the fractured bedrock in the central portion of the island. Groundwater flow within the unconsolidated deposits closely follows the surface topography (Gates et al. 1971; Schafer 1971; Sekora 1973). Most water finds its way into the fractures in the bedrock where it is sorted. All of the potential aquifers on the island are quite thin, have low porosity, or have low permeability. Depth to water varies from approximately 3 m to more than 60 m below ground surface.

Freshwater lakes and ponds are a conspicuous feature of the Shemya Island landscape (Sekora 1973). Fifteen lakes dot the island; most are concentrated in the central part of the island. Most lakes and ponds have poorly defined drainage basins, although those in the western half of the island tend to be more distinct. Many are located near surface-water divides or high points, and a significant portion of the available precipitation is absorbed by surficial and near-surface deposits. Most of the pond basins appear to be phylogenous in nature; many are connected and drained by small or intermittent streams (Collins et al. 1945; Sekora 1973; Valdez et al. 1977). Most were probably formed by locally uneven accumulations of snow, which resulted in uneven growth of tundra vegetation. These retarded patches formed peat less rapidly than did the surrounding areas; thus, enclosed depressions were formed. Alternatively, these lake basins may have formed by local thawing of buried ice wedges or of frozen soils as described by Hutchinson (1957) referring to arctic and subarctic situations. The remaining water is discharged by streams or springs on the southern coastline (Gates et al. 1971; Sekora 1973). Because of south-sloping bedrock, there is no significant runoff to the north. The narrow stream valleys widen near the seacoast.

Virtually every natural water course and pond has been impacted by military-related construction activities spanning 50 years, including three runways, some 130 km of roads, and numerous structures.

Detailed limnological studies are lacking for Shemya Island, but Amchitka Island, which was subject to extensive environmental study, serves as a comparative model. Stream systems on Amchitka Island are not highly productive (Valdez et al. 1977). The majority of the basal energy enters the streams as dissolved organic carbon and as detritus.

The streams of Shemya Island meander through tundra-covered watersheds (Sekora 1973). Overhanging banks can provide cover for small fish (Valdez et al. 1977), and, in some upstream areas, the banks meet and form a solid turf roof over the stream. The substrate of these lowland streams is predominantly soft, organic muck, which supports an abundance of perennial plants. There are very few gravel or rocky areas except near the outlets.
The flow of lowland streams in the western Aleutians markedly varies, even on a daily basis (Clark 1945; Collins et al. 1945; Merritt 1977; Murie 1959; Sekora 1973). The volume of water in a stream depends on both the amount of immediate rainfall and the moisture in the relatively thin soil layer and tundra mat of the watershed. Shemya receives relatively little precipitation from March through June (Overland 1981; Overland and Pease 1982). This allows the moisture content of the soil and organic mat to appreciably decrease, and stream volume during this time should decrease accordingly. During wetter seasons, when soils are saturated, any small amount of precipitation results in considerable increases in stream flow. This sponge effect is a very significant phenomenon because the increased flow provides strong flushing action in the watershed and streams and aids in the release and distribution of organic detritus through the stream systems (Collins et al. 1945; Sekora 1973; Valdez et al. 1977).
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THE PEOPLE AT THE END OF THE WORLD:

The Western Aleutians Project and the Archaeology of Shemya Island

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