COAST BATHOLITH AND TAKU PLUTONS
NEAR KETCHIKAN, ALASKA: PETROGRAPHY,
GEOCHRONOLOGY, GEOCHEMISTRY, AND
ISOTOPIC CHARACTER

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STERN*

ABSTRACT. Cretaceous and Tertiary intrusive rocks of the Ketchikan-Hyder area belong to a continental-margin calc-alkaline magmatic province of gabbro to granite generated near a subduction zone. Although these rocks increase in K₂O content from west to east, and most elements form coherent trends on chemical variation diagrams, we recognize six individual suites that were emplaced during brief, discrete time intervals, are geographically localized, and had sources at depth that can be identified more strongly with their enclosing terrane than with any simple model of subduction-zone magmatism.

The Coast batholith, bounded on the west by the Coast Range megalineament, contains three of these suites: (1) the central orthogneiss suite (about 127 Ma) of migmatitic quartz diorite to granodiorite which constitutes the remnants of the root zone of a continental-margin magmatic arc; (2) the western tonalitic suite (55–57 Ma) of elongate bodies of foliated biotite-hornblende quartz diorite and tonalite intruded along the west flank of the gneiss complex and probably formed from sources that included significant contributions of melt from the central orthogneisses; (3) the eastern granite suite (52–54 Ma) of massive plutons of granodiorite and granite which probably formed by mixing and fractionation of subduction-related magmas and melts from Phanerozoic crustal rocks of intermediate to silicic composition.

The accreted Taku terrane, west of the Coast Range megalineament, is intruded by Moth Bay pluton (135 Ma?) and by the Taku suite (89–93 Ma) of hornblende-biotite quartz diorite and tonalite which probably formed by melting of Phanerozoic mafic crustal rocks or fractionation of subduction-related magmas. Both Taku terrane and Coast batholith were intruded by a mid-Tertiary suite (32–19 Ma) of small plutons of gabbro to Mo-mineralized granite which did not evolve from Coast batholith rocks but had more primitive sources like those of Taku terrane.

The history of plutonic intrusion within Taku terrane is, prior to mid-Tertiary, distinct from that of Coast batholith. The generation of the western and eastern suites of Coast batholith may have occurred when the eastern part of Taku terrane was juxtaposed along the western part of the older marginal arc (gneiss complex) during the Paleocene and Eocene.

INTRODUCTION

One of Dave Wones’ primary geologic interests was the evolution of continental batholiths. He worked on batholiths in several parts of

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North America, including the Sierra Nevada batholith of the Pacific margin and the Paleozoic plutonic belts of the Atlantic margin. He was interested in the origin of both, was fond of comparing the two, and sought to discover their common and distinct features. It was this spirit of inquiry that helped motivate this study.

The largest exposed batholith of North America is found along the Pacific margin in the Coast Mountains (formerly Coast Range), a rugged range that extends 1700 km from northern Washington state through British Columbia and southeast Alaska and into the Yukon Territory (fig. 1). Early reports by Dawson (1881, 1888) noted that the Coast Mountains consist largely of a considerable belt of granite and granitoid rocks, generally of gray color, and many rich in hornblende. Brooks (1906) described the rocks as an "igneous complex" that was "intruded as a great batholithic mass" of Mesozoic age, composed of "diorites,

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Fig. 1. Location map showing the Coast batholith. Outlined is the Ketchikan area of southeast Alaska, which includes parts of Coast batholith and the Insular belt.
granodiorites, and granites”. Today this complex is recognized as one of the major circum-Pacific batholiths (Roddick, 1983a), and its origin is of considerable interest as an example of continental growth related in some way to movement and interaction at the boundaries of crustal plates. The batholith has been given a variety of names, including Coast Range batholith (Buddington, 1927), Coast Crystalline Belt (Hutchinson, 1970), Coast Plutonic Complex (Douglas and others, 1970: and other Canadian authors), and simply Coast batholith (Barker, Arth, and Stern, 1986). The batholith is bounded on the west by a mountainous archipelago or Insular Belt composed of Phanerozoic sedimentary and volcanic rocks and granitic intrusives (Brooks, 1906) of several stratigraphically distinct terranes (Berg, Jones, and Coney, 1978) thought to have accreted to the continent during Mesozoic time (Monger, 1977). The batholith is bounded on the east by a plateau region or Intermontane belt that is also composed of stratigraphically distinct terranes that abut the Rocky Mountains farther to the east and were accreted to North America by the end of Triassic time (Monger, Souther, and Gabrielse, 1982).

Three hypotheses, not mutually exclusive, are now extant to explain the origin of the batholith: (1) The batholith represents the eroded remnant of a continental margin magmatic arc produced by melting in response to eastward-dipping subduction of oceanic crust beneath the western margin of North America during the Mesozoic to Tertiary (Monger, Souther, and Gabrielse, 1972; Dickinson, 1976; Griffiths, 1977). (2) The crystalline belt resulted from Mid-Triassic to early-Tertiary magmatism above an eastward-dipping subduction zone combined with crustal thickening as the eastern part of the Insular plate was overridden by the North American plate in the late Cretaceous to early Tertiary (Godwin, 1975). (3) The Coast Plutonic Complex represents the eroded remnant of a high-grade metamorphic and granitic “welt” that developed during a Cretaceous to early Tertiary collision between the continental margin of North America on the east and an amalgamated group of accreted terranes to the west (Monger, Price, and Tempelman-Kluit, 1982).

In this study we attempt to clarify the plutonic history and genesis of a key part of the batholith by examining the geochronology, petrography, major- and minor-element chemistry, and isotopic composition of Sr and Nd of plutons in the Ketchikan 2° × 1° map area (Berg and others, in press) in southeast Alaska. It was in this area and slightly to the north that Buddington (1927) reported a west-to-east increase in the K2O content of plutons in the batholith, a feature now commonly ascribed to subduction of an oceanic plate from the west (for example, Dickinson, 1975). The Ketchikan area (fig. 2) incorporates the batholith proper as exposed on Portland Peninsula, as well as intrusive rocks of the accreted Taku terrane (Berg, Jones, and Coney, 1978) exposed to the west on Cleveland Peninsula, Revillagigedo Island, and southwest Portland Peninsula. Thus this area also provides an opportunity to
Fig. 2. Generalized geologic map of the Ketchikan area showing locations of the analyzed samples. Major units as delineated by Berg and others (in press). The Taku terrane is separated from the Coast batholith by the Coast Range Megafoldament.
observe if batholith development was influenced by the possible collision of an outboard terrane with the continental margin, and how plutons within that outboard terrane may be related to the plutons of the batholith.

THE COAST BATHOLITH AND TAKU TERRANE IN THE KETCHIKAN AREA

The general geologic features and earlier studies of the Coast batholith are summarized by Buddington and Chapin (1929), Roddick and Hutchison (1974), and Roddick (1983b). Recent petrologic-geochemical studies of the plutonic rocks include those of Hutchison (1982) in the Skeena River area just south of the Ketchikan area in British Columbia and Barker, Arth, and Stern (1986) in the Skagway area in the northern part of the Alaska panhandle and in adjacent British Columbia. Rocks of the Ketchikan area are mapped by Berg and others (in press) at a scale of 1:250,000. This study examines plutonic rocks of Portland Peninsula, Revillagigedo Island, and Cleveland Peninsula (fig. 2).

The principal units of the Coast batholith in the Ketchikan area are exposed on Portland Peninsula: migmatitic orthogneisses of the central core (unit gc), elongate plutons of foliated quartz diorite and tonalite of the western zone (unit wt), and massive plutons of granodiorite and granite of the eastern zone (unit eg). These rocks enclose screens, roof pendants, and xenoliths of amphibolite- to granulite-facies paragneiss and schist of unknown age (unit P), grouped as the Tracy Arm terrane (Monger and Berg, 1984), and may be partly or wholly the metamorphosed equivalents of rocks in adjacent terranes. The batholith is bounded on the west by the east arm of Behm Canal and by bedded rocks of Paleozoic or Mesozoic age (units u and a). The bedded rocks are dominated by mafic to intermediate volcanics, metagraywacke, and metapelite which show progressive greenschist to amphibolite facies metamorphism from west to east, overprinted locally by contact metamorphism. Those rocks that lie west of the Coast Range Megalineament (Brew and Ford, 1978) or Insular Trough (Roddick and Hutchison, 1974) are now included in the Taku terrane by Monger and Berg (1984). The batholith is bounded on the east, at the head of Portland Canal, by rocks of the Stikine terrane.

Rocks of the Taku terrane (Berg, Jones, and Coney, 1978) are exposed on Revillagigedo Island, Cleveland Peninsula, and southwest Portland Peninsula. These include late Paleozoic to Mesozoic metasedimentary (unit P) and metavolcanic (unit a) rocks. These rocks are metamorphosed progressively from greenschist facies on the southwest to amphibolite facies on the north and east. Plutons intruding these rocks include a body of quartz diorite at the south end of Revillagigedo Island near Moth Bay (unit mb). A large body of foliated tonalite occupies northern Revillagigedo Island and the adjacent Cleveland Peninsula (coherent part of unit ti). A swarm of plagioclase-porphyritic quartz diorite stocks is scattered across Revillagigedo Island and Cleveland Peninsula to the west (small area of unit ti).
Small mid-Tertiary plutons (unit mi) in the area include the molybdenum-bearing granites at Quartz Hill in the center of Portland Peninsula, and at Burrough’s Bay on Cleveland Peninsula (location 29), and gabbro on southern Revillagigedo Island. The molybdenum-bearing rocks were described by Hudson, Smith, and Elliott (1979) and Hudson, Arth, and Muth (1981).

Petrography

Buddington (1927) and Buddington and Chapin (1929) reported modal averages for 78 samples taken along several waterways crossing the batholith between 54°40’ and 57°N lat in southeast Alaska. They noted that granodiorite, granite, and tonalite are the dominant rock types and that there is much more petrographic variation across the axis of the batholith than there is parallel to it. They suggested that the southwestern part of the batholith, in a belt 5 to 15 km wide, is tonalite: the core, 15 to 25 km wide, has the average modal composition of a granodiorite and is composed predominantly of granodiorite, granite, and tonalite; and the eastern part, 15 to 25 km wide, is granite. They noted that the tonalite forming the southwest part is present throughout southeastern Alaska and adjacent British Columbia. This zone was later called the tonalite sill belt by Brew and Ford (1978).

On a transect across the batholith along Stikine River (56°40’N) Buddington noted that, in spite of general increases from west to east of alkalies (both of $K_2O$ and $Na_2O$) and silicity, the series of sections examined did not show a uniform gradation from west to east but abrupt changes from a belt of tonalite to one predominantly of granodiorite, to one largely of granite.

In this study of the Ketchikan area we report new modal analyses from plutons in the western and eastern zones of the batholith (units wt and eg, respectively) and in the Taku terrane (units ti and mb). Rocks in the core of the Coast batholith (unit gc) are now recognized as an older migmatitic orthogneiss suite that is predominantly granodiorite but includes (in IUGS terminology, 1973) quartz diorite, tonalite, quartz monzodiorite, and granodiorite (Barker and Arth, 1984).

Modal analyses of the more massive Coast batholith plutonic rocks bounding the migmatitic gneisses are given in table 1 and plotted on a ternary modal diagram in figure 3. Samples from the west side of the batholith (samples AK-9, 14, 33) are essentially devoid of K-feldspar and are classified as hornblende-biotite quartz diorites and tonalite. Rocks on the east side (samples AK-15, 16, 17, 18, 19, 20) are biotite-hornblende granodiorites and granite, all containing more than 10 percent K-feldspar. Sphene is conspicuous in the eastern rocks.

Plutons of Taku terrane on Revillagigedo Island and Cleveland Peninsula (samples AK-1, 30, 31, 32) are biotite-hornblende tonalite and quartz diorite (fig. 5). They are petrographically distinguished from the quartz diorites and tonalite of the western zone of Coast batholith on Portland Peninsula by lower abundances of hornblende, by the presence
of garnet as a minor phase, and in some samples (AK-1, 30) by magmatic epidote.

Detailed petrographic relations and crystallization histories for the Ketchikan area samples will be reported elsewhere. In general the Taku tonalitic plutons contain magmatic biotite, plagioclase, and garnet and/or epidote displaying evidence for growth in early, intermediate, and late stages of crystallization (criteria as delineated by Barker and others, 1975). Garnet is found as euhedra and subhedra in plagioclase and against biotite and quartz. It probably was the first phase to crystallize. Hornblende is generally early, although in some samples it forms overgrowths on clinopyroxene. K-feldspar and quartz are generally of late growth. Comparison of our observations to results of experimental studies suggests that Taku tonalitic magmas were of moderate water content and crystallized mostly in the middle crust, although growth of garnet at the liquidus may imply lower-crustal conditions for the onset of magma crystallization. This is in general agreement with the 8 ± 1 km depth of emplacement suggested by Crawford and Hollister (1982) for the Ecstall pluton in the Insular Belt just south of the Ketchikan area, and distinct from emplacement in the deeper crust as suggested for some of our samples by Zen and Hammarstrom (1984).

The western tonalite suite of Coast batholith is medium to coarse grained, foliated, homogeneous quartz diorite and tonalite. The foliated or gneissic fabric is due to flow during emplacement rather than subsolidus deformation. Crystallization began with hornblende and plagioclase and continued to conclusion with these plus biotite and quartz. Traces of K-feldspar are interstitial and late.

Rocks of the eastern granite suite of Coast batholith are medium to coarse-grained, massive, and relatively homogeneous. These samples show differences in sequence of crystallization, depending on SiO₂ content. Rocks having SiO₂ in the low sixties, (AK-65, AK-17), had early hornblende, plagioclase, and sphene; intermediate hornblende, plagioclase, quartz, and biotite; and late growth of those four phases and K-feldspar. In rocks having SiO₂ in the mid sixties (AK-19), K-feldspar crystallized at the intermediate as well as late stage. For rocks having SiO₂ in the high sixties, plagioclase was the dominant early phase, K-feldspar was of early to late growth, and a small proportion of the quartz was early, the remainder intermediate and late.

The mid-Tertiary granite (AK-15) is massive and medium-to-coarse-grained. Crystallization commenced with minor hornblende and subhedral plagioclase, continued with plagioclase, quartz, K-feldspar, and biotite and probably concluded with these four phases.

**GEOCHRONOLOGY**

Previously published ages in the area are by the K-Ar method. These were compiled and adjusted to IUGS decay constants by Smith and Diggles (1981). Some results are on mineral pairs, such as biotite
### Table 1

*Modal analyses of samples from plutons of the Ketchikan area, southeast Alaska*

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<td>20-44</td>
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<td>16</td>
<td>7</td>
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<td>T</td>
<td>T</td>
<td>T</td>
<td>7</td>
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<td>13</td>
<td>17</td>
<td>3</td>
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<td>1</td>
<td>T</td>
<td>4</td>
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<td>19</td>
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<td>1</td>
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<td>42</td>
<td>-</td>
<td>26</td>
<td>10</td>
<td>3</td>
<td>T</td>
<td>T</td>
<td>T</td>
<td>T</td>
<td>1</td>
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<tr>
<td>Mid-Tertiary granite at Burrough's Bay</td>
<td>AK-29 ***</td>
<td>17</td>
<td>-</td>
<td>45</td>
<td>33</td>
<td>2</td>
<td>-</td>
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<td>Portland Peninsula (Coast batholith)</td>
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<td>Migmatitic gneiss of central part in Boca de Quadra (unit gc)</td>
<td>Range**</td>
<td>40-62</td>
<td>29-43</td>
<td>1-33</td>
<td>8-25</td>
<td>3-15</td>
<td>2-28</td>
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### Western plutons (unit wt)

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<th>36</th>
<th>T</th>
<th>11</th>
<th>19</th>
<th>13</th>
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<th>T</th>
<th>T</th>
<th>T</th>
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<td>AK-9</td>
<td>48</td>
<td>40</td>
<td>-</td>
<td>15</td>
<td>21</td>
<td>16</td>
<td>T</td>
<td>-</td>
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<td>13</td>
<td>18</td>
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### Eastern plutons (unit eg)

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<th>2</th>
<th>10</th>
<th>1</th>
<th>1</th>
<th>T</th>
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<td>42</td>
<td>11</td>
<td>18</td>
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<td>38,28</td>
<td>30</td>
<td>23</td>
<td>5</td>
<td>2</td>
<td>T</td>
<td>1</td>
<td>T</td>
<td>T</td>
<td>-</td>
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<td>34</td>
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<td>12</td>
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<td>20-38</td>
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<td>29</td>
<td>9</td>
<td>1</td>
<td>T</td>
<td>-</td>
<td>T</td>
<td>-</td>
<td>-</td>
<td>granodiorite</td>
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<tr>
<td>AK-20</td>
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### Mid-Tertiary granites of Portland Peninsula (unit mi)

#### Quartz

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<th>Hill***</th>
<th>32-33</th>
<th>32-34</th>
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<th>≤2.5</th>
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<td>32</td>
<td>35</td>
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### Abbreviations used

- **Plag.**: plagioclase
- **An**: An content of plagioclase
- **K'spar.**: K-feldspar
- **Qz.**: quartz
- **Bi.**: biotite
- **Hb.**: hornblende
- **Opaq.**: opaque minerals
- **Sph.**: sphene
- **Ap.**: apatite
- **Ep.**: epidote
- **Gar.**: garnet
- **T**: trace (<1%)
- **-**: none observed

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**Barker (unpub. data).

***See Hudson and others (1981) for description of the mineralized rocks of Quartz Hill and Burrough' Bay*
Fig. 3. Ternary modal diagram showing samples from major plutonic rock units of the Ketchikan area (excluding those of the central migmatisite complex). Rocks of Revillagigedo Island and western Portland Peninsula are quartz diorite and tonalite; those of eastern Portland Peninsula are granodiorite and granite (IUGS 1973 nomenclature).

and hornblende, from the same sample. For the most part these pairs lack agreement, so that the K-Ar results cannot be used to measure the time of igneous emplacement. In the present study we obtained representative samples of the major plutonic units and dated them by the U-Th-Pb method on zircon. The results are given in table 2 along with the previously determined K-Ar ages for hornblende and biotite from the same localities.

The most reliable of the three zircon ages is the $^{238}\text{U}/^{206}\text{Pb}$ age, because $^{238}\text{U}$ is the most abundant isotope of U and provides the largest and most accurately measurable amount of radiogenic lead. Samples that yield similar $^{238}\text{U}/^{206}\text{Pb}$ and $^{235}\text{U}/^{207}\text{Pb}$ ages (termed concordant ages) are particularly reliable, because they require no model-dependent concordia projections to assign an age. Ages determined from the $^{207}\text{Pb}/^{206}\text{Pb}$ ratio are not reported here, because in geologically young samples they are exceedingly sensitive to common-lead corrections.

The oldest known pluton of Revillagigedo Island or Cleveland Peninsula is the quartz diorite of Moth Bay (sample AK-1, unit mb, fig. 2). Replicate analyses yield $^{238}\text{U}/^{206}\text{Pb}$ ages of 137 and 135 my. These may represent the time of emplacement, a minimum age, or possibly the presence of inherited zircon. However, all methods show this pluton to be at least 96 my old. The large tonalite body on northern Revillagigedo
Table 2
Age determinations on plutons of the Ketchikan area, southeast Alaska. Methods for U-Th/Pb as described by Stern and others (1981)

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<th>Sample No.</th>
<th>Pb (ppm)</th>
<th>U (ppm)</th>
<th>Th (ppm)</th>
<th>208Pb/206Pb</th>
<th>207Pb/206Pb</th>
<th>204Pb/206Pb</th>
<th>206Pb/238U</th>
<th>207Pb/235U</th>
<th>208Pb/232Th</th>
<th>K-Ar ages* (in my)</th>
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<tr>
<td>Quartz diorites and tonalites of Revillagigedo Island and Cleveland Peninsula (Taku Terrane)</td>
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<td>AK-1</td>
<td>25.0</td>
<td>348.</td>
<td>87.5</td>
<td>0.88557</td>
<td>0.37186</td>
<td>0.02205</td>
<td>137.</td>
<td>131.</td>
<td>96.</td>
<td>112.</td>
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<td>AK-1 Replicate</td>
<td>7.3</td>
<td>348.8</td>
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<td>290.</td>
<td>28.7</td>
<td>0.59472</td>
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** Barker, Stern, and Arth (unpub. data).
*** Bradfield Canal is the quadrangle adjacent to Ketchikan on the north.
and adjacent Cleveland Peninsula (samples AK-31 and AK-32, unit ti, fig. 2) gives near concordant results of 91 and 89 my, respectively, suggesting emplacement in that interval. One quartz diorite stock (AK-30 at Bushy Point, unit ti, fig. 2) of the many on Revillagigedo Island was dated and yields discordant results. However, the $^{238}\text{U}/^{206}\text{Pb}$ age of 92.7 my is similar to the hornblende K-Ar age of 89.6 my and may be close to the time of igneous intrusion. Thus, the major intrusive events on Revillagigedo Island were Cretaceous and probably occurred at about 135 my and 89 to 93 my ago. Several small stocks were intruded in Oligocene to Miocene time (Hudson, Arth, and Muth, 1981; Smith and Diggles, 1981).

Several samples of orthogneisses in the core of Coast batholith on Portland Peninsula have been dated by T. W. Stern as part of an adjunct study (Barker and Arth, 1984) and show U/Pb ages of 117 to 140 my (table 2) with one concordant result at 127 my. Thus the orthogneiss suite is of probable Early Cretaceous age.

Tonalitic to quartz dioritic intrusive rocks forming the western zone of Coast batholith were sampled at 2 localities within the Ketchikan map sheet (AK-9 and AK-33, unit wt, fig. 2) and by Richard Koch at a locality in the adjacent Bradfield Canal quadrangle to the North (RK-2348). All three samples yield near concordant or discordant results and strongly suggest that the western zone plutons were intruded at 55 to 57 my ago.

The granodiorite to granite plutons on the east side of Coast batholith were sampled at five localities. Three of these (AK-18, AK-20, and AK-65, unit eg, fig. 2) give similar near-concordant or discordant results suggesting intrusion at 52 to 54 my ago. One sample of massive granodiorite (AK-16, fig. 2) that shows no foliation or low-rank mineral alteration yields highly discordant results of 116 and 99 my for U-Pb, 127 my for Th-Pb, and 51 my for the K-Ar method on hornblende. We tentatively interpret the U-Th-Pb results to be the consequence of relict zircon and suggest that the pluton is the same age (52–54 my) as the other three plutons noted above. A sample from a small plug of coarsely porphyritic granite (AK-15, unit mi, fig. 2) yielded unexpectedly young ages of 18 to 27 my by all methods and is of probable Oligocene to Miocene age. Thus the major emplacement of plutons on eastern Portland Peninsula occurred in early Eocene time, but some small stocks are of Oligocene to Miocene age.

A diagram summarizing the history of intrusion in the Ketchikan area is given in figure 4. Both Portland Peninsula and Taku terrane experienced plutonism in early Cretaceous or earlier time. From mid-Cretaceous to mid-Tertiary time, however, the terranes experienced separate and discreet episodes of plutonism. The major intrusive episode in Taku terrane was completed in the brief interval of 89 to 93 my ago, and no plutons of this age are known on Portland Peninsula. Major plutonism on Portland Peninsula took place between 58 and 53 my ago, and no plutons in this age range are known in the adjacent Taku
Fig. 4. Time correlation diagram showing comparative intrusive history of Taku terrane and Coast batholith in the Ketchikan area. Only mid-Tertiary magmatic events are common to both terranes. An early Cretaceous event may have been synchronous in both terranes, but more evidence is needed.

terrane. Previously reported argon ages on Revillagigedo Island become progressively younger from 90 my on the west to 55 my on the east, a feature that has been interpreted as the result of cooling due to uplift (Smith and Diggles, 1981; Sutter and Crawford, 1985). We suggest an alternative interpretation: that argon ages were partially to completely reset from west to east by the mid-50's thermal event on Portland Peninsula or by overthrusting at that time of the Taku rocks by rocks from the east (Crawford and Hollister, 1982). Partial resetting of conventional K-Ar ages and $^{40}$Ar/$^{39}$Ar age spectra was demonstrated by Hanson, Simmons, and Beuce (1975). Although in some cases resetting may produce recognizably disturbed spectra (Harrison and McDougall, 1980), in cases where events are closely spaced in time, as in the Ketchikan area, disturbance in the spectra may not be recognizable. Thus we hypothesize that the disturbance that produced a 35 my progression in argon ages in Taku terrane may have been closely related to tectonism and Coast batholith plutonism during a 35 my period in the early Tertiary.

The next plutonic activity in the area is mid Tertiary in age and is common to both the Portland Peninsula and Taku terrane. This and other stratigraphic evidence suggest that the two terranes were juxta-
### Table 3

**Chemical composition of plutonic rocks of the Ketchikan area, southeast Alaska**

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<th>Na2O</th>
<th>K2O</th>
<th>TiO</th>
<th>P2O5</th>
<th>MnO</th>
<th>SrO</th>
<th>BaO</th>
<th>SrO</th>
<th>CO2</th>
<th>Cl-</th>
<th>F</th>
<th>H2O</th>
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<td>.29</td>
<td>.21</td>
<td>-</td>
<td>.33</td>
<td>-</td>
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Table 3 (Continued)

Coast batholith of Portland Peninsula

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<th>AK-16</th>
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<td>55°40'54&quot;</td>
<td>55°54'40&quot;</td>
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<td>130°06'00&quot;</td>
<td>130°08'30&quot;</td>
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<td>130°07'45&quot;</td>
<td>130°01'00&quot;</td>
<td>130°03'00&quot;</td>
<td></td>
</tr>
</tbody>
</table>

composition in weight percent

| 57.33 | 61.10 | 61.80 | 65.78 | 67.81 | 68.44 | 68.67 | 70.67 |
| 17.44 | 17.40 | 17.71 | 15.99 | 16.08 | 15.42 | 15.71 | 14.79 |
| 1.78 | 1.84 | 2.11 | 1.99 | 1.44 | 1.55 | 1.29 | 0.86 |
| 5.06 | 3.30 | 2.59 | 2.32 | 1.55 | 1.73 | 1.39 | 1.15 |
| 3.53 | 2.40 | 2.31 | 1.82 | 1.01 | 1.25 | 1.02 | 0.45 |
| 6.55 | 5.22 | 4.95 | 4.06 | 3.50 | 3.47 | 2.69 | 1.42 |
| 3.54 | 3.60 | 3.76 | 3.34 | 4.04 | 3.53 | 3.60 | 4.28 |
| 1.83 | 2.86 | 2.45 | 3.12 | 3.43 | 2.78 | 3.69 | 4.74 |
| 1.01 | .86 | .63 | .57 | .31 | .54 | .43 | .32 |
| .29 | .25 | .26 | .18 | .10 | .15 | .12 | .09 |
| .11 | .10 | .11 | .09 | .11 | .07 | .06 | .06 |
| .09 | .11 | .09 | .06 | .09 | .09 | .09 | .03 |
| .14 | .23 | .12 | .19 | .23 | .16 | .22 | .10 |
| .02 | .03 | .02 | .02 | .03 | .02 | .03 | .02 |
| .32 | .01 | .19 | .02 | .04 | .03 | .02 | .03 |
| .02 | .01 | .19 | .02 | .04 | .03 | .02 | .03 |
| .05 | .03 | .05 | .05 | .04 | .05 | .07 | .04 |
| .81 | .79 | .74 | .52 | .23 | .64 | .30 | .26 |
| .04 | .08 | .08 | .07 | .06 | .06 | .07 | .05 |
| 100.04 | 100.19 | 99.98 | 100.23 | 100.08 | 99.99 | 99.47 | 99.36 |
| .13 | .02 | .02 | .02 | .02 | .02 | .03 | .02 |
| 100.01 | 100.17 | 99.96 | 100.21 | 100.06 | 99.97 | 99.44 | 99.35 |

in parts per million

| 47. | 64. | 71. | 71. | 110. | 54. | 79. | 111. |
| 0.8 | 1.5 | 1.0 | 1.4 | 1.5 | 1.0 | 1.5 | 0.9 |
| 803. | 899. | 800. | 760. | 534. | 739. | 758. | 242. |
| 21. | 32. | 37. | 26. | 22. | 21. | 34. | 69. |
| 45. | 60. | 64. | 46. | 39. | 44. | 56. | 78. |
| 27. | 29. | 27. | 22. | 21. | 26. | 23. | 37. |
| 5.2 | 6.9 | 4.1 | 3.9 | 4.4 | 4.9 | 3.9 | 5.2 |
| 1.21 | 1.53 | .98 | .84 | .81 | 1.03 | .86 | .48 |
| 3.8 | 5.5 | 3.0 | 2.6 | 3.3 | 2.9 | 2.4 | 1.4 |
| .50 | .68 | .37 | .40 | .50 | .44 | .39 | .41 |
| .16 | .27 | .27 | .27 | .27 | .27 | .27 | .27 |
| 1.5 | 1.4 | .90 | .80 | 2.0 | 1.2 | 1.0 | 1.9 |
| .17 | .22 | .30 | .15 | .34 | .19 | .11 | .30 |
| 3.2 | 3.6 | 3.5 | 3.2 | 5.1 | 3.7 | 4.4 | 3.7 |
| .40 | .91 | .88 | .73 | 1.27 | 1.04 | .60 | 1.03 |
| 0.4 | 7.7 | 10.2 | 7.7 | 8.8 | 5.5 | 10.3 | 13.9 |
| - | 3.5 | 3.3 | 2.1 | 4.8 | 2.8 | 4.1 | 3.0 |
| 14.0 | 11. | 4.75 | 7.99 | 4.53 | 9.38 | 4.00 | 2.15 |
| 28.3 | 10.1 | 8.9 | 9.1 | 7.1 | 10.9 | 7.4 | 1.9 |
| 16.1 | 11.3 | 6.1 | 8.1 | 3.7 | 9.3 | 4.2 | 1.8 |
| 109. | 78. | 68. | 77. | 57. | 91. | 56. | 29. |
posed by mid-Tertiary time. We speculate that the early Tertiary magmatic event in Coast batholith and possible thermal event in Taku terrane marked the joining of Taku and Tracy Arm terranes at the Coast Range megalineament.

MAJOR-ELEMENT CHEMISTRY

Major-element analyses of the plutons are given on table 3. The rocks show a large range of SiO₂ content of 55.8 to 72.6 percent. Kuno and AFM diagrams for the rocks (fig. 5A and B) show that the Cretaceous and early Tertiary rocks are calc-alkaline, whereas the Mid-Tertiary granites are more alkalic. The rocks are balanced in alkali content, showing neither strongly sodic or potassic trends on a ternary Na-K-Ca diagram (fig. 5C), although one Taku pluton (AK-32) is sodic.

Harker variation diagrams for the oxides of Fe, Ca, and Mg (not illustrated) show a coherent declining pattern as a function of SiO₂ content, as is common in many igneous provinces. The Cretaceous and early Tertiary rocks are moderately high in Al₂O₃ content, in the range 15.4 to 18.6 percent. SiO₂ contents do not exceed 69 percent. The Mid-Tertiary granites have higher SiO₂ contents, ranging from 70.6 to 76.7 percent, and lower Al₂O₃ of 12.7 to 14.8 percent (table 3, and Hudson, Arth, and Muth, 1981).

K₂O contents of the Coast batholith and mid-Tertiary plutons increase from near 2 percent at 55 percent SiO₂ to nearly 5 percent at 73 percent SiO₂ (fig. 6A). Taku plutons show an opposite trend which distinguishes them from the other rocks. In general the K₂O contents of the massive plutons are lower than those of the central orthogneisses at a given SiO₂ content. Na₂O contents for all the Ketchikan area plutons fall in the limited range of 3.1 to 4.3 percent over the entire range of SiO₂, as illustrated in figure 6B.

Geographic variations of K₂O content is illustrated in figure 6A. Pre-Miocene plutons of Cleveland Peninsula, Revillagigedo Island (symbol T), and western Portland Peninsula (W) have K₂O in the range 1.2 to 2.5 percent. K₂O for most samples of the core gneisses of Portland Peninsula is in the range 2 to 3.5 percent (Barker and Arth, 1984). K₂O contents of samples from eastern Portland Peninsula (E) are 2.4 to 3.7 percent. The highest K₂O contents are found in the Miocene to Oligocene granites (M) that are found scattered through the area. These have K₂O contents of 4.3 to 5.8 percent and are generally associated with molybdenite deposits (Hudson, Arth, and Muth, 1981). Thus the overall west to east increase in K₂O applies only to the more voluminous plutons of early Tertiary and Cretaceous age.

TRACE-ELEMENT CHEMISTRY

The trace-element chemistry of the Ketchikan area plutons (table 3) is distinguished by generally high Sr contents, which range from 500 to 1200 ppm in all rocks except the Miocene granites. Even these latter, evolved plutons have Sr of 240 to 260 ppm. Rb contents are generally
Fig. 5(A) Plot of Na₂O + K₂O versus SiO₂ (in wt percent) showing fields for tholeiitic, calc-alkaline, and alkalic suites (boundaries from Kuno, 1969). Symbols for plutons are: T for Taku terrane of Revillagigedo Island and Cleveland Peninsula, W. for western Portland Peninsula (Coast batholith), E for eastern Portland Peninsula (Coast batholith), and M for mid-Tertiary granites. (B) Ternary plot of MgO, total iron as FeO, and Na₂O + K₂O (in wt percent) showing fields for tholeiitic, calc-alkaline, and alkalic suites (boundaries from Kuno, 1969). (C) Ternary Ca-Na-K (in atom percent) diagram showing alkali balance of most of the Ketchikan area plutons.
Fig. 6(A) Plot of K$_2$O versus SiO$_2$ (in wt percent) showing plutons from the Ketchikan area, as well as the field for orthogneisses from central Portland Peninsula. The older orthogneiss suite is generally more potassic than the younger plutonic suites for a given SiO$_2$ content. (B) Plot of Na$_2$O versus K$_2$O showing the constancy of Na$_2$O throughout the suite.

Fig. 7. Plots of Rb (A) and Sr (B) versus SiO$_2$ content for Ketchikan area plutons, showing the general trends common to coherent magmatic suites.
low, most samples containing less than 80 ppm; even the evolved granites contain less than 150 ppm. Although Rb and Sr show extreme values, they generally exhibit the respective trends of increase and decline with SiO$_2$ content commonly observed in a coherent magmatic province (fig. 7A and B). However, Taku rocks show a decrease of Rb as SiO$_2$ increases, analogous to the trend noted for K$_2$O. Ba contents of the entire suite show little coherence and range from 700 to 2030 ppm.

Rare earth element (REE) patterns for the suite are shown in figure 8. Patterns are generally distinct for each rock type and geographic area. Heavy rare earth contents (Yb, Lu) for all the rocks are 2 to 10 times those of chondrites, but light rare earths and Eu anomalies vary with rock type. The quartz diorites and tonalites of the Taku terrane (fig. 8A) show very similar patterns, lacking Eu anomalies and having light rare earths (La to Nd) of 20 to 70 times chondrites. Tonalites of the western Coast batholith have patterns (fig. 8B) similar to each other and

Fig. 8. Rare earth plots for major plutonic suites of the Ketchikan area.  
(A) Tonalitic plutons of Revillagigedo Island and Cleveland Peninsula (Taku Terrane).  
(B) Early Tertiary tonalite and quartz diorite plutons of western Portland Peninsula (Coast batholith).  
(C) Eocene granodiorite and granite plutons of eastern Portland Peninsula (Coast batholith).  
(D) Mid-Tertiary granites of Portland Peninsula and Cleveland Peninsula (Coast batholith and Taku terrane).
only differ from those of Taku terrane in having a convex-up light REE pattern and very small negative Eu anomalies. The granodiorites and granites of eastern Portland Peninsula (fig. 8D) are different from the tonalites in that they have distinct negative Eu anomalies, light rare earths of 50 to 110 times chondrites, and some show more fractionated patterns of lower heavy-rare-earth content. The Miocene plutons (fig. 8C) have large negative Eu anomalies and light rare earths of 60 to 210 times chondrites.

High-valence cations such as Zr and Hf are relatively constant through the area, as illustrated for Hf in figure 9A. They show no differences between rock groups. Ta, Th, and U show modest increases as SiO₂ content increases, as illustrated for U in figure 9B. These three elements are much higher in evolved mid-Tertiary granite AK-29.

![Diagram](image_url)

Fig. 9. SiO₂ versus trace-element plots for two high-valence cations (Hf and U) and a ferromagnesian element (Co).
The ferromagnesian trace elements, including Sc, Cr, Co, and Zn, decline as SiO₂ increases. This trend is illustrated for Co in figure 9C. As expected, these elements follow trends similar to that of MgO and FeO.

**ISOTOPIC COMPOSITION OF SR AND ND**

Strontium isotopic compositions for the plutons are given in table 4. All the rocks have initial $^{87}\text{Sr}/^{86}\text{Sr}$ ratios (SIR) in the range 0.7041 to

| Table 4 |
| Sr isotopic measurements on whole-rock samples from plutons of the Ketchikan area, southeast Alaska |

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<tr>
<th>Sample number</th>
<th>Rb in* ppm</th>
<th>Sr in* ppm</th>
<th>Rb/Sr</th>
<th>$^{87}\text{Sr}/^{86}\text{Sr}$ measured</th>
<th>Age in my</th>
<th>Age reference</th>
<th>$^{87}\text{Sr}/^{86}\text{Sr}$ initial</th>
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*Rb and Sr analyses by X-ray fluorescence spectrometry by George Sellers. Uncertainties in Rb and Sr concentrations are 10 and 6 percent, respectively, at the 95 percent confidence level.

**Measured** $^{87}\text{Sr}/^{86}\text{Sr}$ ratios were normalized to an $^{87}\text{Sr}/^{86}\text{Sr}$ ratio of 0.11940. The uncertainty in the $^{87}\text{Sr}/^{86}\text{Sr}$ ratio is 0.00015 at the 95 percent confidence level. Fourteen analyses of NBS SRM 987 gave a mean value of 0.71016 ± 0.00003 (1 sigma).

***Uncertainty in initial $^{87}\text{Sr}/^{86}\text{Sr}$ is less than 0.00018 at the 95 percent confidence level for all samples. Uncertainty includes that for concentration measurements, isotopic ratio measurement, and reported age.

†Arth and Barker (unpub. data).

Age references (column 7):
- 1. Age based on U-Th-Pb age of zircon, as reported in table 2.
- 2. Age based on K-Ar determination on "biotite and chlorite" reported by Hudson and others (1979).
- 3. Age based on K-Ar determination on hornblende from the same locality reported by Smith and Diggles (1981).
- 4. Age estimate based on 2 K-Ar determinations of 54 my on hornblends from nearby localities reported by Smith and Diggles (1981).
- 5. Data based on Rb-Sr results on whole rocks reported by Hudson and others (1981).
0.7064. Within this range, groups are observed that correspond to geographic areas. Plutons of the Taku terrane have the lowest SIR values of 0.7042 to 0.7050. Plutons of western Portland Peninsula are the highest and most uniform, having SIR of 0.7063 to 0.7064. Plutons of eastern Portland Peninsula fall mostly in the range 0.7054 to 0.7061, although one sample (AK-16) has a significantly lower value of 0.7046. The mid-Tertiary granites show values in the range 0.7047 to 0.7051.

The overall range of SIR for Ketchikan area plutons is similar to that found in magmatic arcs at convergent plate margins. Some magmatic arcs along continental margins that are underlain by older continental crust have higher values, ranging to 0.708 (see, for example, Hawkesworth, 1982, p. 533). SIR values greater than 0.710 are found in some western North America batholiths emplaced in areas underlain by Precambrian crust, such as the Pioneer batholith of Montana (Arth and others, 1986) and parts of the Idaho batholith (Fleck and Criss, 1985). We infer from these observations that Ketchikan area magmas probably were not derived from and did not interact with significant amounts of crust of the Precambrian craton, and that the area is underlain by less radiogenic crust of Paleozoic or younger age, perhaps similar to the country rocks exposed at the surface.

In our study of the Coast batholith in the Skagway area (Barker, Arth, and Stern, 1986), the observed range of SIR was similar to that of the Ketchikan area, and we invoke a similar explanation. The accreted rocks composing the crust to the northeast and southwest of the Coast batholith consist largely of oceanic igneous rocks (island arc, rift and intraplate basalts, and minor intrusive rocks) and immature sedimentary rocks (Berg, Jones, and Coney, 1978: Berg and others, in press). The Sr-isotope ratios of most of these rocks initially ranged from about 0.703 to the value for sea water (about 0.708). Their Rb/Sr ratios are not high nor are they ages pre-Paleozoic, so that the $^{87}\text{Sr}/^{86}\text{Sr}$ ratios in these rocks during Cretaceous and early Tertiary time were in the range 0.703 to 0.709. Because the ratios of potential primary magmas from a deep source would probably be in the range 0.703 to 0.706, as observed in many oceanic magmatic arcs, the effect on the SIR of interaction with or melting of wall rocks would not be particularly noticeable.

Our as-yet-unpublished data on the Central orthogneisses indicate that they had $^{87}\text{Sr}/^{86}\text{Sr}$ during the late Cretaceous to early Tertiary of 0.705 to 0.707. Partial melts from gneisses would be unsuitable as significant contributors to the Taku or mid-Tertiary plutons, because these plutons are consistently more isotopically primitive than the gneisses. Partial melts of the gneisses could have contributed heavily to the magmas of the western and eastern plutons of Coast batholith. The SIR of the plutons, particularly those of the western tonalitic suite, are similar to the $^{87}\text{Sr}/^{86}\text{Sr}$ ratios of the gneisses at the time of pluton emplacement. Many of the eastern granites are also isotopically similar to the gneisses, although some have lower values (AK-16 at 0.7046). Thus the gneisses could not have acted as the only source of the eastern
suite, and a more primitive component is needed, such as a subduction-zone magma.

Neodymium isotopic compositions for the plutons are given in table 5. All of the rocks have initial \(^{143}\text{Nd}/^{144}\text{Nd}\) ratios (NIR) in the range 0.5123 to 0.5127. Taku plutons and mid-Tertiary granites occupy the higher part of this range, having values greater than 0.51245. Coast batholith plutons occupy the lower part of the range, having NIR less than 0.51245. The lower values for Coast batholith rocks could reflect a larger component of older or more silicic crustal rocks in their source than was present in the source for Taku plutons. This is illustrated in figure 10, a NIR-SIR diagram on which the fields for various possible source rocks are shown, as compiled by Zartman (1984). On this plot the field for Taku plutons is distinct from that of the Coast batholith. Mid-Tertiary granites fall on or near the field of Taku plutons. Taku plutons fall at the intersection of fields for island arc volcanic rocks and young or mafic crustal rocks. Coast batholith rocks fall in the fields for crustal rocks but are not far displaced from the field for island arcs (fields were constructed by Zartman to encompass 80 percent of the observed values and do not therefore represent absolute limits). Within the field for Coast batholith, a dotted line separates the eastern granodiorites and granites from the western tonalites. This subdivision primarily reflects the higher SIR values of the western tonalites.

| Table 5 |
| Nd isotopic measurements on whole-rock samples from plutons of the Ketchikan area, southeast Alaska |

<table>
<thead>
<tr>
<th>Sample Number</th>
<th>Sm in* ppm</th>
<th>Nd in* ppm</th>
<th>Sm/Nd</th>
<th>(^{143}\text{Nd}/^{144}\text{Nd}) measured</th>
<th>Age*** in my</th>
<th>(^{143}\text{Nd}/^{144}\text{Nd})**** initial</th>
</tr>
</thead>
<tbody>
<tr>
<td>Revillagigedo Island and Cleveland Peninsula (Taku Terrane)</td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Tonalites and quartz diorites</td>
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<td></td>
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<tr>
<td>AK-1</td>
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<td>16</td>
<td>.20</td>
<td>.51257</td>
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<td>.51246</td>
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<td>AK-30</td>
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<td>21</td>
<td>.23</td>
<td>.51273</td>
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<td>AK-32</td>
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<td>15</td>
<td>.20</td>
<td>.51260</td>
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<td>.51253</td>
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<tr>
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<tr>
<td>AK-29</td>
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<td>18</td>
<td>.18</td>
<td>.51253</td>
<td>22</td>
<td>.51251</td>
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<td>Portland Peninsula (Coast batholith)</td>
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<td>Western plutons</td>
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<td>.51243</td>
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<td>AK-18</td>
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<td>.51240</td>
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<tr>
<td>AK-15</td>
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<td>37</td>
<td>.14</td>
<td>.51265</td>
<td>19</td>
<td>.51264</td>
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</table>

*Sm and Nd analyses by neutron-activation method. Uncertainties are 10 percent at the 95 percent confidence level.
**Measured \(^{143}\text{Nd}/^{144}\text{Nd}\) ratios were normalized to a \(^{146}\text{Nd}/^{144}\text{Nd}\) ratio of 0.72190. The uncertainty of the measured ratio is less than .00005 at the 95 percent confidence level.
***Age references as in table 4.
****Uncertainty in initial \(^{143}\text{Nd}/^{144}\text{Nd}\) is less than .00005 at the 95 percent confidence level. Uncertainty includes that for concentration measurements, isotopic ratio measurement and reported age.
Fig. 10. Plot of initial $^{87}\text{Sr}/^{86}\text{Sr}$ ratio (SIR) versus initial $^{145}\text{Nd}/^{144}\text{Nd}$ (NIR) for plutons of the Ketchikan area, showing fields for possible magma-sources (Zartman, 1984). Mid-Tertiary granites plot on and just above field for Taku plutons. Coast batholith field is subdivided by a dotted line to separate western tonalites (w) from eastern granodiorites and granites (e).

In general, the Sr and Nd isotopic data emphasize the distinction between Taku plutons and Coast batholith plutons and also suggest that both groups may contain components in their source of subduction-related magma and relatively immature crust. The mid-Tertiary granites do not represent a further evolution of Coast batholith magmas but instead reflect a reversion of magmas toward more primitive sources, perhaps the same as that of Taku plutons.

DISCUSSION

Each of the tools applied in this study helps further to delimit the nature of magmatism and the tectonic setting in which it may have occurred. Petrographic study of the rocks has served for many years to provide distinguishing mineralogical features that allow subdivision of
the rocks in the field. Inferences regarding depth of emplacement are more controversial, being strongly dependent on the interpretation of experimental phase relations and textures that are as yet not completely known. It is encouraging to realize, however, that petrographic subdivisions proposed by Buddington and Chapin (1929) still retain validity and reflect major breaks in the time of plutonism. Magmatic epidote and garnet are features of Taku tonalitic rocks, whereas near absence of K feldspar and lack of garnet characterize the western tonalites of Coast batholith. In the absence of geochronologic study of every rock body, petrographic criteria continue to be essential to recognizing magmatic belts and have been used in recent years by Brew and Morrell (1983) to delineate plutonic belts in southeast Alaska.

The U-Pb geochronology indicates that magmatism was not continuous through the Cretaceous and early Tertiary but instead was distinctly episodic. Each episode appears to have lasted only a few million years and was geographically limited to a region that paralleled the continental margin. During the Cretaceous and early Tertiary the episodes of plutonism were completely distinct in the Taku terrane and Coast batholith, but both areas experienced mid-Tertiary magmatism. This may indicate that the two terranes were geographically separated until the early Tertiary. Argon ages show a continuum across the area that may have been produced in early Tertiary time by heat associated with Coast batholith magmatism or by overthrusting of Taku rocks by rocks (such as the central gneisses) from the east and consequent suppression and reheating of Taku rocks. Perhaps both processes were active as the two terranes were joined in early Tertiary time.

The major and trace-element chemistry of the Cretaceous and early Tertiary rocks is similar to that of calc-alkaline magmatic arcs elsewhere. The collective continuity of the data on most variation diagrams is a feature often taken to indicate a genetic relation among magmatic bodies. However, in this case, the temporal and geographic separation of the magmatic episodes does not support any simple fractional crystallization or other direct mechanism of magmatic differentiation that would link the plutons genetically. Instead we take the chemical coherence of the rocks and their similarity to compositions of other convergent-plate-margin suites to reflect a common aspect to the magmatism that was present in each episode, namely the presence of a subduction-related mafic magma that enters the crust and provides a fairly uniform "starting" composition for other processes to modify. The generally mafic to intermediate character of the country rock to the west of the orthogneiss suite could provide a key to understanding the general geographic polarity of magma composition in Cretaceous and early Tertiary time. Melting of metamorphosed mafic to intermediate volcanic or plutonic rocks in the deep crust (Taku terrane or orthogneiss equivalents) could provide magmas of tonalitic to granodioritic composition, and these could interact with subduction-related mafic magma to produce the quartz dioritic or tonalitic plutons of Taku terrane and the
western Coast batholith. In an analogous way, the presence of intermediate to siliceous igneous rocks and mature sedimentary rocks to the east of the orthogneiss suite (Stikine equivalent?) could provide a source for magmas of near "minimum-melt" granite composition that might interact with subduction-related mafic magmas to produce the granodiorite to granite plutons of the eastern Coast batholith.

The isotopic composition of Sr and Nd lend further support to hybrid and young sources for the magma groups. All the suites fall close to the overlap in the fields for island-arc magmas and young or mafic crustal rocks. Cretaceous Taku plutons show stronger arc affinity, whereas early Tertiary Coast batholith plutons are closer in isotopic composition to the orthogneiss suite that forms the older core of the batholith. No component of Precambrian crust is apparent in the data, and we presume that no Precambrian crust is present at depth under either terrane. The isotopic data also serve to distinguish the mid-Tertiary magmas as distinct from those of Coast batholith and not simply the late expression of an evolving magma system at depth.

CONCLUSIONS

The results of this study indicate that the Coast batholith of the Ketchikan area, Alaska, is restricted to the Portland Peninsula. It is composed of 3 major magmatic suites: a magmatically differentiated core suite of about 127 my-old orthogneiss, a western group of 55 to 57 my-old quartz diorite and tonalite, and an eastern group to 52 to 54 my-old granodiorite and granite. The origin of these plutonic rocks was the consequence of 2 major events. At about 127 my ago a continental margin magmatic arc developed in response to subduction, and a suite of quartz diorite, tonalite, quartz monzodiorite, and granodiorite was emplaced into country rock composed primarily of metavolcanic rocks, metagraywacke, and metapelitic (Barker and Arth, 1984). About 70 my later, in Paleocene to Eocene time, this terrane was uplifted and intruded on both flanks. On the west flank quartz diorite and tonalite were emplaced at 55 to 57 my ago. On the east flank granodiorite and granite intruded at 52 to 54 my ago.

The Taku terrane, to the west of the batholith, experienced a different plutonic history. It was intruded by quartz dioritic to tonalitic to granodioritic plutons in two events. At about 135 my? ago, a large quartz dioritic pluton was emplaced on southern Revillagigedo Island. At 89 to 93 my ago, a swarm of tonalitic plutons and a tonalite-granodiorite batholith were emplaced on Revillagigedo Island and on Cleveland Peninsula. The eastern margin of the Taku terrane experienced the thermal effects associated with the 55 to 57 my plutonism in the Coast batholith or of overthrusting by rocks from the east at that time. Thus, the Tracy Arm and Taku terranes may have been juxtaposed in early Tertiary time, and this event may have triggered the generation of magmas that formed the massive parts of the Coast batholith.
The chemical and isotopic characters of the magmas of both the Taku terrane and Coast batholith are like those of other subduction-related, continental-margin magmas. Taku plutons show stronger island-arc affinity; Coast batholith rocks may contain significant contributions from remelting of the central orogheisses. Sources for tonalites of west Portland Peninsula and Taku terrane were dominantly mafic, whereas those of granodiorite and granite of eastern Portland Peninsula contained more intermediate rocks and metasediments. The mid-Tertiary plutons do not represent more evolved aspects of the early Tertiary Coast batholith plutonism or simple remelting of Coast batholith rocks. They appear to be evolved from distinct and more primitive sources, perhaps similar to those that generated Taku plutons.

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REFERENCES


