the oceanic Aleutian arc is the best place in the world to study the role of arc magmatism in forming continental crust.
QuickTime™ and a decompressor are needed to see this picture.

W Aleutian lavas with compositions ~ continental crust
oceanic Aleutian plutons ~ continental crust
W Aleutian lavas with compositions ~ continental crust

oceanic Aleutian plutons ~ continental crust
major elements in continental crust like “calc-alkaline” arc andesite & dacite

Kelemen CMP 1995
making lavas ~ continental crust

- wet and oxidized 50-60% “cumulates”
- primitive andesite ~ 20-30% “cumulates”
- mixing 60-80% “cumulates”
mid-ocean ridge lavas don’t “go there”
Kelemen et al. 2003, AGU Monograph Chapter 11
Aleutian lavas E of Adak

\[
\text{wt\% SiO}_2 \quad \text{molar Mg}\#
\]

Kelemen et al. 2003 AGU Ch11, Singer et al. 2007, WAVE dredging expedition 2005
lavas with molar Mg# > 0.5

Kelemen et al., 2003 Treatise on Geochemistry
no recycled continental seds in W Aleutian primitive andesites

Kelemen et al. Treatise on Geochemistry 2003
Making lavas ~ continental crust

- Mixing 60-80% "cumulates"
- Wet and oxidized 50-60% "cumulates"
- Primitive andesite ~ 20-30% "cumulates"
no enriched “granite” (yet?)
mixing 60-80% “cumulates”

making lavas ~ continental crust

wet and oxidized 50-60% “cumulates”

primitive andesite ~ 20-30% “cumulates”
crust formed from primitive basalt

- intermediate andesitic lavas & plutons
- dense, mafic cumulates

crust formed from primitive andesite
QuickTime™ and a decompressor are needed to see this picture.
Upper Crust: 6.0 - 6.5 km/s
Middle Crust: 6.5 - 7.3 km/s
Lower Crust: 7.3 - 7.6 km/s
Upper mantle: 7.8 - 8.1 km/s

Holbrook et al. Geology 1999; Shillington et al. G-cubed 2004
1994 Aleutians Experiment
R/V Maurice Ewing

Shillington et al., 2004, Van Avendonk et al., 2004; Kelemen et al. 2003 AGU Monograph Chapter 13
intermediate andesitic lavas & plutons

dense, mafic cumulates

MOHO?

need Vs, Q to distinguish pyroxenite & garnet granulites from peridotite ± partial melt
intermediate andesitic lavas & plutons

dense, mafic cumulates

COOLING MELT IN SHALLOW MANTLE?
crystal fractionation + reaction just below mantle at the base of arc crust?

(this is NE Japan, no comparable data for the Aleutians!)

Zhao et al., JGR 1992
intermediate andesitic lavas & plutons

dense, mafic cumulates

COOLING MELT IN SHALLOW MANTLE?
W Aleutian lavas with compositions ~ continental crust

oceanic Aleutian plutons ~ continental crust
andesitic lavas & plutons

dense, mafic cumulates

delamination, foundering

relamination
Drewes et al. 1961 USGS Bull 1028S; Hein et al. 1984 USGS Bull 1609
“There are no ICP-MS trace element analyses for any Aleutian plutons. Other than USGS U/Pb data for 4 samples, there are no Pb or Hf isotope ratios. There are 11 Sr isotope ratios and 2 Nd isotope ratios for Aleutian plutons east of Adak (Perfit et al. 1980; McCulloch & Perfit 1981).”
QuickTime™ and a decompressor are needed to see this picture.
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QuickTime™ and a decompressor are needed to see this picture.

let’s go!
primitive andesites with >100 ppm Ni and Mg# >70% form via reaction between melts of subducting eclogite and residual peridotite in the mantle wedge.
fractionation + reaction w mantle at base of crust

fractionation + reaction w mantle at base of crust

87Sr / 86Sr vs Sr (ppm) graph

DSr = 0.025

Basalt 437 ppm Sr
Ma / Mc = 0.10
Ma / Mc = 0.70
Ma / Mc = 0.90

High-Sr Andesite & Dacite 1000-2000 ppm Sr
Ma / Mc = 0.97

Peridotite 7.6 ppm Sr
Ma / Mc = 0.99

Yogodzinski & Bryant, Goldschmidt 2008
trace elements also distinguish continental and oceanic crust
Aleutian lavas

Graphs showing the Sr in clinopyroxene (ppm) versus Mg-number in clinopyroxene, and Dy/Yb (N) versus molar Mg#. The graph includes data for Primitive Adakite (V38), Primitive Adakite (ADK), Primitive Adakite (KCP), and Basalt (all samples).

Yogodzinski & Kelemen EPSL 1998; Kelemen et al AGU Mon 2003
no recycled continental seds in western Aleutian primitive andesites
also Ringwood, 1974
Rising diapirs of low density metasediment rise into the overlying mantle wedge.

"subduction erosion" and "delamination" lead to slow subduction of metasediments and lower crust.
some island arcs have lavas ~ continental crust

Kelemen et al AGU Monograph 2003
all samples, $0.5 < \text{Mg\#} < 0.7$

Kelemen et al., Treatise on Geochem 2003
Aleutian lavas

Kelemen & Yogodzinski Geology 2007
major elements in continental crust like “calc-alkaline” arc andesite & dacite

≥ Fo90 olivine

Fe$^{3+}$/Fe$^{2+}$

molar Mg#

wt% SiO2

Kelemen CMP 1995
“relamination” of buoyant material

Hacker et al., EPSL 2011; Behn et al. Nature Geosci 2011
all samples, $0.5 < \text{Mg}\# < 0.7$

Kelemen et al., 2003 Treatise on Geochem
not all arcs produce primitive andesites

Kelemen et al., 2003 AGU Monograph Chapter 11
basaltic arcs don’t have trace elements ~ continental crust

compiled data from literature
trace elements in primitive and high Mg# andesites ~ continental crust

some western Aleutian lavas with > 54 wt% SiO2 & Mg# > 0.4

Kelemen et al. 2003, Singer et al. 2007, WAVE dredging expedition 2005
most Aleutian plutonic rocks have compositions ~ continental crust

Kelemen et al., 2003, AGU Monograph Chapter 11
QuickTime™ and a decompressor are needed to see this picture.
no recycled continental seds in W Aleutian primitive andesites

Kelemen et al. 2003 Treatise on Geochemistry
global subduction component = melt
(recycled continental sediments? not always …)

Kelemen et al 2003 Treatise on Geochemistry
Ingenstrom Depression

Buldir Basin
high temperature basalts near low temperature primitive andesites

Ingenstrom Depression
primitive lavas, molar Mg# > 0.6

Yogodzinski et al., WAVE dredging expedition, 2005
mixing primitive basalt & enriched “granite”?

primitive basalt plus lower crustal melt

Sr/Y
molar Mg#