tion across the Coast Range batholith in the Skagway area, and from a variety of outlying plutons west of the batholith in the Yakutat Bay region (latitudes 59°-60°N), indicate widespread interactions with meteoric groundwaters. In the Yakutat Bay area, the plutons with K-Ar ages younger than 50 m.y. have widely varying $\delta D = -72$ to $-148$, compared to $\delta D = -69$ to $-90$ for all but one sample in the 50 to 225 m.y. age grouping, suggesting that the major meteoric-hydrothermal episodes occurred during the Eocene and Miocene. Relatively small meteoric water/rock ratios ($<0.1$) prevailed, as none of the $\delta^{18}O$ values show any clear-cut evidence of alteration ($\delta^{18}O_{quartz}=7.4$ to 11.8; $\delta^{18}O_{feldspar}=5.7$ to 10.0). However, in the section across the Coast Range batholith, $\delta^{18}O_{feldspar}=+10.3$ to $-4.0$, $\Delta^{18}O_{quartz-feldspar}=0.4$ to 10.5, and 85% of the rocks have very low $\delta D$ values of $-100$ to $-167$. These data indicate that a major portion of the batholith, particularly the quartz monzonite-rich eastern part, interacted with meteoric-hydrothermal convective systems that involved water/rock ratios of 0.3 to 1.4. Many of the quartz diorites are similarly affected, but their primary igneous $\delta^{18}O$ values are also unusually high, suggesting derivation from, or assimilation of, high-$^{18}O$ metasediments or altered volcanic rocks. An even greater proportion of the Coast Range batholith is depleted in deuterium in the Skagway area than was observed previously in British Columbia 800 km to the SE at latitudes 54°-55°N, but in both areas deep (≈5 km?) circulation of meteoric ground waters accompanied the later stages of pluton emplacement. In particular, the eastern portions of the Coast Range batholith must have been emplaced at relatively shallow depths.

V 95

### THE KODIAK-CHUGACH-CHICHAGOF TERRANES... A NEWLY DEFINED ALASKAN BLUESCHIST BELT

Robert B. Forbes
John R. Carden (both at: Geophysical Institute, Univ. of Alaska, Fairbanks, Alaska 99701)
William Connelly (Earth Sciences Board, University of California, Santa Cruz, California 95064)

Blueschists southwest of the previously reported Seldovia terrane (Forbes and Lanphere, 1973), have been discovered on the northwest coast of Kodiak and Afognak Islands. Blueschists were also discovered in the Chugach Range, near Chitina, by P. Metz in 1974; and G. Plafker collected blueschist float from the Hubbard Glacier, St. Elias Range in 1975. The earlier work of Reed and Coats (1941), indicates blueschists and melange on the northwest coast of Chichagof Island. The blueschist localities are closely associated with dismembered ophiolites and melange, and are bounded on the oceanward side by Jura-Cretaceous turbidites.

Metamorphic grade increases toward the continental plate in the blueschist bearing terranes. The blueschists are dominated by crossite-epidote-albite assemblages. Lawsonite and jadeitic pyroxene have been discovered in Kodiak terrane assemblages. The blueschists are intercalated with greenschists suggesting that the P/T conditions were mainly those of the high temperature blueschist subfacies.

K-Ar mineral ages from Seldovia, Port Graham and Kodiak give early-Jurassic (180-190 m.y.) cooling ages. Dated cross-cutting diorite plutons (Loney et al., 1975) indicate that the Chichagof terrane is older than 164± 5 m.y.. Dobretsov (1975) has described 180 m.y. old blueschists from the Koryak Mtns. of Siberia, which may be correlative.

The above terranes appear to be segments of a formerly contiguous North Circum-Pacific blueschist belt which was formed in a zone of plate convergence.

V 96

### AGES OF THE WHITE MOUNTAIN MAGMA SERIES AND RELATED INTRUSIVES OF NORTHERN NEW ENGLAND

K. A. Foland Department of Geology
Henry Faul University of Pennsylvania
C. A. McCabe Philadelphia, Pa. 19174

All of the major and almost all of the minor stocks and complexes related to the White Mountain Magma series in New Hampshire, Maine, and Vermont have now been dated. With the addition of our new K-Ar data it is clear that these intrusives postdate the major Appalachian deformational events and that the igneous activity producing the similar complexes occurred over a period exceeding 100 m.y., ending about 100 m.y. ago. The general concordance of Rb-Sr and K-Ar results indicate that K-Ar biotite ages can be interpreted as emplacement ages for these generally small and shallow bodies. The magmatic activity, represented by approximately 35 intrusive centers, appears to have occurred in two major pulses about 175 and 115 m.y. ago. Only a small number of complexes have ages which are appreciably different from these two times. The geographic distribution of ages is neither simple nor regular. Most of the older intrusives are in central and northern New Hampshire, but the younger group is spread over the southern part of the three state region. The age distribution does not appear to be simply related to a "linear trend" that could be thought to correlate all of these rocks. These results argue against a model which would attribute the origin of the Mesozoic intrusives to simple motion of a lithospheric plate over a single, presumably stationary, mantle hot plume.

V 97

### MANTLE ISOCHRONS AND THEIR IMPLICATIONS FOR THE ISOTOPIC COMPOSITION OF SUBCONTINENTAL LITHOSPHERE

Christopher Brooks (Dept. of Geology, Univ. of Montreal, Montreal, Canada)
David James (Dept. of Terrestrial Magnetism, Carnegie Institution of Washington, Washington, D. C. 20015)
Stanley Hart (Dept. of Geol. & Geophys., Mass. Inst. of Tech., Cambridge, Mass. 02139)

Continental volcanic rocks commonly exhibit higher and more variable $^{87}Sr/^{86}Sr$ ratios than volcanic rocks of oceanic regions. While the observed difference in isotopic composition between volcanics of continents and oceans is often attributed to effects of continental crustal contamination, close examination of available evidence shows crustal contamination to be implausible on numerous grounds. It appears rather that strontium isotopic compositions of continental volcanic rocks are inherited from ancient lithospheric mantle from which the magmas are derived. By this view, the high and variable isotopic ratios reflect both the antiquity and gross heterogeneity of subsolidus continental lithosphere, long isolated from the rest of the mantle.

Convincing evidence that the isotopic identity of ancient lithospheric mantle is preserved in young continental mafic volcanic rocks is found in the systematic whole rock variation of $^{87}Sr/^{86}Sr$ with Rb/Sr. This variation, common in young continental volcanics, defines pseudo-isochrons which give ages grossly in excess of the true age of volcanism. We interpret these pseudo-isochrons as containing real age information and therefore term them mantle isochrons. Mantle isochrons in concert with other Sr-isotopic data show that the continental lithosphere is ancient, heterogeneous, and undepleted. Continental lithospheric mantle may be a magma source in plume, rift, or subduction zone environments and the derived magmas will bear the ancient isotopic imprint of that mantle material.

V 98

### THORIUM/URANIUM FRACTIONATION AS AN INDICATOR OF PETROGENETIC PROCESSES

Leon T. Silver (Division of Geological and Planetary Sciences, California Institute of Technology, Pasadena, California 91125)

A mean Th/U ratio, ~4, seems to characterize most terrestrial, lunar, and meteoritic igneous materials and major patterns of lead isotopic evolution develop principally in systems with Th/U about 3.7-4.0. Some important crustal igneous subsystems show systematic deviations from these values. Such fractionation generally is attributed to the geochemical behavior of the large lithophile actinide ions in various enriched minor phases. This probably is true in highly differentiated series with higher Th and U levels (>8 and 2 ppm). A different fractionation mechanism may be more important in some lower concentration systems. Isotope dilution mass spectrometric studies of U and Th in diverse igneous feldspar separates reveal significant U and Th partitioning into them with drastic fractionation of Th/U (values 0.2-3.0). Alkali feldspars in granitic rocks display partition coefficients (feldspar/total rock) of about 0.005-0.02 for U and 0.001-0.004 for Th; Th/U ~ 0.5-3.0. In plagioclase in gabbros, tonalites, and granodiorites with lower Th and U, the coefficients appear larger (U ~ 0.1-0.4, Th ~ 0.04-0.2) but Th/U appears lower (Th/U ~ 0.2-2.0) than in K-feldspars. Limited data suggests some pyroxenes and other major minerals may also fractionate Th/U to lower ratios. Differences in ionic radius and uranium oxidation states may contribute to the undefined fractionation mechanism. Processes of primary differentiation (fractional crystallization, partial melting) involving gabbroic systems seem to reflect this fractionation. Oceanic tholeiites, and massive gabbroic complexes display generally low Th/U values. Their lead isotopes reflect reservoirs with more normal Th/U ratios. This suggests limits on the number of fractionation cycles, mantle mixing, and/or reservoir dimensions for primary basaltic systems. Th and U and their associated lead isotope systems can be used with lanthanide R.E.E. to assist in development of petrogenetic models.

V 99

### Nd ISOTOPIC VARIATIONS AND PETROGENETIC MODELS

*D. J. DePaolo*
G. J. Wasserburg (The Lunatic Asylum, Div. of Geol. and Plan. Sci., Calif. Inst. of Tech., Pasadena, Calif. 91125)

$^{147}$Sm $\alpha$-decays to $^{143}$Nd so that $^{143}$Nd/$^{144}$Nd reflects the time-integrated Sm/Nd environment of a sample. The increase in 143/144 in a reservoir with chondritic Sm/Nd is 1.2% in 4.5AE. There exists sufficient variation of Sm/Nd to cause sizeable effects in 143/144. Young samples were measured to elucidate the nature of their source regions. An oceanic high Fe, Ti basalt (113152) and alk. basalt (113031), a continental alk. basalt (BCR-1), an apatite (Khibiny massif) and two reagent "normals", NN1 and NN2, were analyzed. Isotopic ratios of NN2 and BCR-1 normalized to 148/144=0.241572 are tabulated. Following the pioneering work of Lugmair, *et al.* (EPSL *27*, 79) our 143/144 data are presented relative to the total rock value for Juvinas (0.51278), the present value of a chondritic reservoir. Data are given as deviations from this value in parts in $10^4$ ( $\epsilon$ ) and show a wide range. Nd in the source regions of the rock samples evolved in an environment of approximately chondritic Sm/Nd (±5%) over the history of the earth. *Small* variations exist, reflecting long time scale differences of Sm/Nd in the source regions. The low Sm/Nd observed in alkali basalts cannot reflect an ancient source region with low Sm/Nd as $\epsilon$ is near zero. REE patterns of alkali basalts must thus reflect relatively recent fractionation from a source with essentially chondritic relative abundances. Study of initial $^{143}$Nd/$^{144}$Nd in conjunction with REE patterns promises to contribute important petrogenetic information.

| Sample | 142/144 | 143/144 | 145/144 | 146/144 | 150/144 |
|---|---|---|---|---|---|
| BCR-1 | 1.14178 | .51263 | .34844 | .72187 | .23639 |
|  | ±7 | ±3 | ±2 | ±3 | ±2 |
| NN2 | 1.14177 | .511924 | .348404 | .721894 | .236385 |
|  | ±5 | ±19 | ±12 | ±16 | ±16 |

| Sample | $\epsilon_{Juvinas}$ | $^{147}$Sm/$^{144}$Nd |
|---|---|---|
| BCR-1 | -2.9 ±0.6 | 0.14 |
| USNM 113152/D | +5.9 ±0.8 | 0.212 |
| 113031/43 | +2.5 ±0.8 | 0.117 |
| Apatite | -2.4 ±0.4 | 0.096 |
| NN1 | -32.7 ±0.8 | —— |
| NN2 | -16.7 ±0.4 | —— |
| Juvinas | 0 | 0.1935 |

V 100

### $^{143}$Nd/$^{146}$Nd NATURAL TRACER OF GEOLOGICAL PHENOMENON

Pierre Richard, Laboratoire de Géochimie et Cosmochimie, Institut de Physique du Globe, Dépt. des Sciences de la Terre Université de Paris 6-7, France
Nobu Shimizu
Claude Allègre (both at: Laboratoire de Géochimie et Cosmochimie, Institut de Physique du Globe. Dept. des Sciences de la Terre, Universite de Paris 6-7 France.

The $^{143}$Nd (product of decay of $^{147}$dm) can be used as $^{87}$Sr as natural tracers for geological phenomenon. Instead of $^{87}Sr/^{86}Sr$ ratio we will use here $^{143}$Nd/$^{146}$Nd ratio. Using a clean column chemistry to separate Nd for other rare earth and high sensitivity, high accuracy mass spectrometry we can measure a difference in $10^{-4}$ in($^{143}$Nd/$^{146}$Nd)*.

Tacking young samples we have shown that alkali basalt has a ratio of $^{143}$Nd/$^{146}$Nd = 0.7080 corresponding to a chondritic closed system mantle (with respect to Sm/Nd ratio) while oceanic tholeites have a ratio of $^{143}$Nd/$^{146}$Nd = 0.70827 corresponding to an open system depleted mantle. Gra-

---

*All ratios will be normalized to Nier's values.