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GEOGRAPHIC VARIATION OF RARE EARTH FRACTIONATIONS IN PLUTONIC ROCKS ACROSS THE PENINSULAR RANGES BATHOLITH, SOUTHERN CALIFORNIA.

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Rare earth element patterns of plutonic rocks (chondrite-normalized) across the Peninsular Ranges batholith vary systematically west to east, transverse to the long axis and structural trends and parallel to known asymmetries in petrologic, geochronologic, and Sr isotopic properties. The abundant tonalites in the western region are characterized by slight light REE enrichment relative to heavy REE. Eastward, patterns become more highly fractionated, showing light REE enrichment and heavy REE depletion. The slope of patterns at any geographic location are largely independent of rock type. However, locally, certain silica-saturated and undersaturated gabbros may show divergent trends. The relative fractionation among the middle and heavy REE indicates differentiation processes involving the observed major phases such as hornblende and plagioclase are not important in producing the basic geographic trends. They may be reflected in more local lithologic variations. The pronounced geographic zonation in REE character correlates strongly with Sr concentration, suggesting a common mechanism for their origin. The systematic nature of these fractionations, their correlation with previously reported Sr isotopic data, and their lack of correlation with lithology, argues against significant upper-crustal contamination with old cratonic components. These features appear to originate in heterogeneous deep-seated sources whose sampling has been selectively activated at a convergent plate boundary.

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RUBIDIUM-STRONTIUM FRACTIONATION DOMAINS IN THE PENINSULAR RANGES BATHOLITH AND THEIR IMPLICATIONS FOR MAGMATIC ARC EVOLUTION.

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The northern 600 km of this Cretaceous batholith, comprised of hundreds of diverse plutons, appears to consist of 12-15 domains. Each domain is a region where rocks of all types (within our limited sampling) show a regular linear covariation of Rb and Sr concentrations. This regularity displays different concentration levels and a different slope and is accompanied by a distinct set of isotopic systematics in each domain. The domains do not disrupt the remarkable zonation of initial Sr ratios in the batholith (Early and Silver, 1973). No independent field or petrographic recognition of the Rb-Sr characterized entities has been made. Very similar rocks occur in adjacent domains. Domains are equant or elongate NNW, up to 200 km long and 30 km wide, parallel to regional tectonic grain. Each domain is interpreted as a region of magmas sampled or differentiated from a mantle source reservoir possessing characteristic trace element levels and Sr isotopic properties. An apparent age of reservoir formation and isolation prior to fractionation and crustal emplacement and an apparent initial Sr ratio at the time of reservoir isolation can be derived for each domain. There is no strong correlation between reservoir apparent ages and initial ratios. Mixing systems involving older granitic crust with primitive mantle seem precluded. We identify similar domains characterized by Rb-Sr systematics in other batholithic and volcanic complexes. We infer these domains to be fundamental loci of chemistry and energy from which magmatic arcs are constructed.

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THE FINGER BAY PLUTON, ADAK, ALASKA AND MAGMATIC EVOLUTION OF THE ALEUTIAN ARC

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As part of a study of patterns of petrologic evolution in the Aleutian arc, magmatic rocks of differing ages from Adak Island have been investigated. New mapping and analytical results are presented for the 10 km^2 Finger Bay Pluton which is intrusive into Eocene(?) Finger Bay sediments and volcanics and belongs to an early plutonic episode in the arc. Major and large ion lithophile element analyses of the Finger Bay Pluton, which ranges from gabbroic to syenitic in composition (48-60% SiO_2) are consistent with differentiation by crystal fractionation. The principal minerals are clinopyroxene ($Wo_{40}En_{43}Fs_{17}$ to $Wo_{45}En_{44}Fs_{11}$), zoned plagioclases (An_{85} to An_{30}) and titanomagnetite. Cumulus magmatic layering is present in the gabbro. Lower greenschist metamorphism has affected both plutonic and country rocks and has resulted in alteration of mafic phases (augite, olivine, biotite, and perhaps hypersthene) to chlorite, actinolite, and opaque oxides. Seven analyzed samples have Sr 87/86 ratios of .7030 to .7036 which correlate with Rb/Sr ratios defining a rough isochron of 120 m.y., an age considerably older than a published K-Ar date of 32 m.y. and the Eocene(?) age of the Finger Bay Group. The isotopic, mineralogic, and chemical characteristics of the Finger Bay Pluton are very similar to those of Plio-Pleistocene calc-alkaline volcanic rocks from Mt. Moffett, Adak Island. Pb isotopic analyses by Sun (1973) are slightly lower in Pb 206 in the Finger Bay Pluton. Magmas of the Miocene plutonic episode, Adak are different from the Finger Bay and Mt. Moffett rocks. Magmatic variations on Adak Island do not imply a simple evolutionary path of Aleutian magmas over time.

Trace Elements and Isotopes I

Madison, Thursday 0900h
F. A. Frey (Massachusetts Institute of Technology) and
A. Hofmann (Department of Terrestrial Magnetism), Presiding

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RARE EARTH ELEMENT EVIDENCE FOR DIFFERENTIATION IN A PLUTONIC IGNEOUS ROCK

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Instrumental neutron activation analysis of rare earth element (REE) abundances in the Tupper-Saranac mangerite from the Adirondack Mountains indicates that the mangerite body is internally differentiated. A lower mafic-rich portion of the mangerite has low total REE abundances and positive europium (Eu) anomalies whereas an upper quartz-rich portion has higher total REE abundances and negative Eu anomalies. Between these two units a thin zone of mangerite has intermediate REE abundances and zero Eu anomalies. At the base of the mangerite a thin border facies also has intermediate REE abundances and zero Eu anomalies plus an Sm/Eu ratio approximating those of undifferentiated lavas. The border facies mangerite is regarded as the parental magma for the Tupper-Saranac mangerite body and indicates that the mangerite is not comagmatic with the adjacent Marcy anorthosite.

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RARE EARTH ELEMENT EVIDENCE FOR COMAGMATIC RESIDUAL GRANITE AND MASSIF ANORTHOSITE

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Instrumental neutron activation analysis of rare earth element (REE) abundances in a granite associated with Marcy anorthosite in the Adirondack Mountains indicates that the granite probably represents residual magma from which Marcy anorthosite accumulated. The granite occurs very near the roof of the Marcy anorthosite massif in anorthosite within an interlayered contact zone between the anorthosite and adjacent mangerite. The granite has an extremely high total REE abundance, a very large negative europium (Eu) anomaly and an approximately linear but inflected REE pattern with considerable light rare earth (La to Sm) enrichment compared to the heavy rare earths (Tb to Lu). The total REE abundance of this granite is considerably higher than that of most granites and is among the highest ever recorded for any rock. The granite is iron, potassium and rubidium rich and is strongly depleted in magnesium and strontium. The strong depletion of both europium and strontium suggests that considerable plagioclase crystallized before the granitic residue solidified.

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GENETIC IMPLICATIONS OF THE RARE EARTH ABUNDANCES OF THE LARAMIE ANORTHOSITE COMPLEX, WYOMING.

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The REE abundances of the various rock types of the Laramie anorthosite complex suggest fractional crystallization dominated the initial magmatic evolution followed by interaction of the residual magma with country rock. The complex consists principally of anorthosite, noritic-anorthosite, norite, hypersthene syenite and hornblende syenite; Sr isotopic data and the age relations of the complex (Subbarayudu, Hills and Zartman, in press) suggest that the anorthosites, norites and hypersthene syenites are comagmatic but that the hornblende syenites are not. The rare earth abundances were determined by isotope dilution mass spectrometry; the anorthosites are characterized by low total rare earth abundances (≈10 ppm) and large positive Eu anomalies, the norites by much higher abundances (ΣREE≈120 ppm) without large Eu anomalies and the hornblende syenites by extremely high REE abundances (ΣREE>150 ppm). The hypersthene syenites vary in both major element composition and REE content, near the anorthosite-syenite contact the hypersthene syenites have low REE abundances (ΣREE≈25 ppm) with large Eu anomalies, abundances increase and the Eu anomalies decrease with increasing distance from the contact. The rare earth element abundances are consistent with the pattern produced by accumulation of plagioclase from a parental noritic-anorthosite magma, with significant incorporation of the country rock involved in the formation of the hypersthene syenites. The high REE abundances of the hornblende syenites indicate they are not comagmatic with the anorthosites.

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RARE-EARTH ELEMENT GEOCHEMISTRY OF THE RONDA HIGH-TEMPERATURE PERIDOTITE

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Eight peridotite (lherzolites and harzburgite) samples from the Ronda high-temperature peridotite massif were analyzed for REE. Because of retrograde metamorphism their mineralogy ranges from spinel to garnet peridotite. As characteristic of high-temperature peridotites, the chondrite normalized REE patterns have relative depletions of light REE (Sm/La normalized ratios of 3 to 6) and unfractionated heavy REE abundances at 1 to 2 times chondrites. The only exception is a very depleted harzburgite with Yb at 0.2 X and La at 0.03 X chondrites. Although REE abundances and relative distribution are roughly correlated with modal mineralogy, there is no correlation with metamorphic grade. Detailed modelling of REE fractionation during melting shows that the peridotites may represent residues from small degrees of melting (<10% except for the very depleted