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Young Upper Crustal Chemical Composition of the Orogenic Japan Arc

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A new geochemical estimate of the young (mainly Palaeozoic age to present) upper crust of the Japan arc shows a dacitic composition in contrast to the idea that andesite is predominant in active orogenic arcs. In trace element compositions, the average upper crust of the Japan arc has higher Sb and As concentrations, and slightly but clearly lower concentrations of alkaline, light rare earth and high field strength elements with respect to previous models of continental upper crusts. As the main Japan upper crust has formed from the Palaeozoic age until the present, we assume that the exposed Japan arc represents the young upper crust of the Japan arc. The surface exposure of the Japan arc is composed principally of Quaternary sediments (21%), Tertiary sediments (14%), Quaternary volcanic rocks (11%), Tertiary igneous rocks (15%), Cretaceous igneous rocks (12%) and others. Lithologically, the surface exposure consists of 41% igneous rocks, 38% non-accretionary sedimentary rocks, 17% accretionary complex rocks, and 4% metamorphic rocks. We have estimated the average abundance of 45 elements in the exposed Japan arc from the area-weighted mean composition of 37 geologic groups. One hundred and sixty six representative specimens from the Japan arc were analysed and sub-divided into the 37 geologic groups based on their ages, lithologies and provenance, as summarised in the 1: 1,000,000 scale geologic map [Geological Survey of Japan, 1992]. The systematic sampling and chemical analysis for the young orogenic upper crust of the Japan arc revealed the following characteristics: 1) The elemental abundance indicates that the young upper crust of the Japan arc has a dacitic composition, in contrast to the idea that andesite is predominant in orogenic arcs. The dacitic composition of the young upper crust of the Japan arc is rather similar to the representative models of the upper continental crust and shield [Taylor and McLennan, 1985; Wedepohl, 1995; Condie, 1993, Gao et al., 1999]. Temporal changes in the average composition are not significant from the Palaeozoic age to the present in the Japan arc, except for some igneous rocks that occurred in relation to the opening of the back arc basin. The observed small difference in the major elements between young and old upper crusts indicates that the essential mechanism of crust formation has not changed from the Archean era to the present. 2) The average concentrations of Sb and As in the sedimentary rocks in the Japan arc are 2-3 times higher than those in the igneous rocks are. High As and Sb values of the average upper crust of the Japan arc are not due to any kinds of magmatism, but due to sedimentation processes. 3) Recycling processes mechanically mix the arc-derived igneous materials to homogenise the chemical composition during erosion, transportation, sedimentation, accretion and uplifting. The idea is supported by the facts a) both of the averages of chemical composition for accretionary complex rocks and non-accretionary sedimentary rocks are similar to the average calculated for igneous rocks on an arc-wide scale, except Sb and As, and b) the large degree of constancy of trace element composition in marine sedimentary rocks is in contrast to the large variety of igneous rocks. Since the contribution of oceanic crust to the composition of arc crust is small, the recycling processes have not changed the bulk upper crustal composition of the active continental margin except increase the Sb and As from sediments. 4) The concentrations of the LILE, HFSE and LREE in the upper crust of the Japan arc are slightly but distinctively lower than in the old crust. These geochemical characteristics are the endogenous inheritance of igneous rocks, because of the similarities in average compositions among igneous rocks, sedimentary rocks and the entire upper crust of Japan. Most igneous rocks vary along the typical fractional crystallisation processes. The contribution of sedimentary rocks to acidic magmas is small, because the amounts of the mafic component included in high silica rocks are distinctly lower than those estimated contribution of sedimentary rocks. 5) We infer that the characteristics of low concentration of the alkaline, light rare earth and high field strength elements of the upper arc crust are inherited from a parental magma derived from sub-arc depleted mantle source provenance during a long-term evolution.

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