Invited Paper in Symposium: The continental crust and its mineral deposits.
University of Toronto, May 14-16, 1979.

VULCANISM ON EARTH THROUGH TIME

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Vulcanism is widespread on earth and apparently always has been. In this respect earth contrasts with the moon, where vulcanism stopped about 3 Ga ago and Mars where it, perhaps, stopped 1 Ga ago. Terrestrial vulcanism before the oldest preserved rocks formed was most likely similar to later vulcanism but the very earliest volcanic activity on earth could have been like that on the moon in composition if the earth acquired its water late during the high impact flux.

Vulcanism plays a vital part in all three stages of lithospheric evolution active on earth today. Basalt forms at divergent plate boundaries; tholeiitic and calc-alkaline rocks, most characteristically andesite, dominate where arcs form above subduction zones and highly potassic volcanics are associated with active continental collision, thickening and fractionation in Tibet. These three processes appear to have operated at plate margins through most of earth history although there is little obvious evidence of continental collision in Archean terrains (3.8-2.5 Ga old). This is because the gneissic Archean terrains preserve only small pieces and deep levels of early the continents that were (in contrast to greenstone-granodiorite terrains) involved in major collisions.

Ultramafic komatiites, forming perhaps 5% of basaltic piles and indicating the existence of ultramafic melts, are peculiar to the Archean and this restriction is presumably related to the greater heat generation of the early earth. Owing to the ambiguities involved in interpreting igneous rock compositions it is not possible to assign unique significance to the restricted occurrence of ultramafic komatiites. Archean convection may have involved either higher temperature melting at shallower depths or more effective eruption of melts from great depths or both.

Although volcanic rocks from early times are almost entirely like those produced at plate margins today and although the tectonic environments in which they occur closely resemble plate margin tectonic environments, non-plate margin (hot spot) vulcanism is recorded from old rocks. Remnants of flood basalts and associated sills and dike swarms formed by rifting episodes are clearly displayed in the Canadian shield; the Keewanawan-Coppermine-Seal Lake-Gardar-Mckenzie dikes represent a particularly good example and the dikes and sills associated with rifting along the Labrador-Cape Smith belt form another. Before 2.1 by ago, dike swarms are the only extensive evidence for rifting. The Ameralik dikes, show that rifting occurred at least as far back as 3.6 Ga. Just as the Canadian shield provides a record of the later impact flux on earth, so it also clearly records a typical pattern of intracontinental hot-spot and rift volcanic activity from 2.15 Ga onward (e.g. Coronation-Athapuscow and Labrador-Cape Smith belts).

Sea-level variations during the Phanerozoic have been interpreted as indicating variations in ridge volume and hence (on an earth of roughly constant volume) of plate creation and destruction rates. In the Precambrian sea-level fluctuations cannot be interpreted in the same way because the sediment record is incomplete and because timing is not adequately resolved. Estimates of episodicity in plate activity in the Precambrian depend mainly on the occurrence of peaks in age abundance. This method is likely to be highly misleading because the preserved areas of particular ages are much too small to be representative of the world at specific times. Thus, the Superior Province, the largest area of Archean rocks, forms about 1% of present continental area and formed about 2% 2.5 Ga ago. As far as the geological record goes, vulcanism has always been active on earth and has been predominantly at plate boundaries. Phanerozoic history indicates some episodicity and the Precambrian was probably similar. Preserved intracontinental rift and hot spot vulcanism extends back to 2.1 and perhaps 2.6 Ga and indicates that the world acted much as it does today.