ASTEROID/COMET MEGA-IMPACT CONNECTIONS OF ARCHAEAN CRUSTAL EVOLUTION: EVIDENCE FROM IMPACT FALLOUT DEPOSITS.

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Geology being a geocentric science focused on endogenic processes, the assumption is generally made that from about 3.8 Ga the impact factor can be neglected in the context of models of crustal evolution, including the emergence of early continental nuclei and plate tectonics. This paradigm is questioned in this paper.

The Late Heavy Bombardment (LHB - 4.2-3.8 Ga) in the Solar system, as preserved on the Moon, requires that the terrestrial upper mantle-crust system has been dominated by interactions between internal mantle processes and extraterrestrial impacts. From about 3.8 Ga the impact flux decreased by two orders of magnitude, from 4-9*10^-13.km^-2.yr^-1 to 3.8-6.3*10^-15.km^-2.yr^-1 (for asteroids Dc >= 18 km), consistent with a cratering rate of 5.9+/-3.5*10^-15.km^-2.yr^-1 estimated for near-Earth asteroids (NEA) and comets (Baldwin, 1985; Ryder, 1990; Shoemaker and Shoemaker, 1996). From the observed number of 6 continental impact structures with Dc >= 100 km (Vredefort [300 km]; Sudbury [250 km]; Chicxulub [170 km]; Woodleigh [120 km]; Manicouagan [100 km]; Popigai [100 km]), assuming an Earth surface occupied by time-integrated >= 80 percent ocean crust since 3.8 Ga, a robust minimum number of post-LHB impacts is defined at >= 30 craters with Dc >= 100 km and >= 10 craters with Dc >= 200 km. However, from lunar crater counts (Wilhelms, 1987) and the present-day asteroid flux the impact incidence was likely to have been higher by at least an order of magnitude than the number of directly observed craters >=200 km (Glikson, 1993; 1996; 1999), with a possible decline in the impact frequency of the largest bodies Dp >= 20 km.

Evidence for mare-scale impact basins in the Archaean emerges from 3.24 Ga-old impact vapour condensation-fallout layers in the Barberton greenstone belt, Transvaal (Lowe and Byerly, 1986; Lowe et al., 1989; Kyte et al., 1992; Byerly and Lowe, 1994), pointing to multiple oceanic impact basin of Dc >= 400 km. The extraterresrial connection of spherulitic fallout deposits is confirmed by Energy Dispersive Spectrometry and laser ICPMS analysis of Ni-rich chromites retained in some of these spherules, indicating anomalously high Ni levels (up to 23% NiO) and PGE levels (up to several hundred PPM). The PGE distribution patterns reflect a complex differentiation history, from vaporisation of the projectile, to stratospheric condensation in melt spherules, to crystallisation within the spherules, interaction with sea water, burial metamorphism and sulphur metasomatism.

Model of crustal evolution need to account for the inevitable magmatic and tectonic consequences of mega-impact events, particularly on impacted geothermally active oceanic crust and lithosphere. The neglect of this factor probably underlies the many inconsistencies between suggested plate tectonic-based models and the stratigraphic and structural elements of Archaean greenstone-granite terrains. A combination of the internal heat engine of Earth and the impact factors is capable of accounting for processes culminating in the formation of the early sialic nuclei, for the spatial and temporal localisation of major faulting and rifting events, and for ensuing plate tectonic patterns.

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