Periodicity of Apollo deep moonquakes revealed from new Apollo event catalogue

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The new event catalogue of Apollo Passive Seismic Experiment has been published by Nakamura (2002). The catalogue was made through the correlation analysis of observed seismograms for all the events of 12,558 numerically at all Apollo seismic stations. It reveals that about 60% of seismic events identified were deep moonquakes, which would not have been done by the eyeball inspection at that time. Deep moonquakes with similar waveforms are grouped into 77 out of 114 identified formally. In addition, 88 new groups are found.

The mechanism of deep moonquakes has been considered (A) tidal stresses between Earth and Moon (Nakamura, 1978; Koyama & Nakamura, 1980), (B) tectonic stresses plus tidal triggering (Toksoz, et al., 1977), and (C) combined mechanism of (A) and (B) (Araki, 2001). I will study the periodicity of deep moonquake occurrences in relation to the mechanism using the new event catalogue.

Poincale mapping of $t_n=f(t_{n-1})$ is made, where t_n is the time difference of deep moonquake occurrences. If events occur in a random manner, plots on t_n/t_{n-1} plane would be random whereas periodic occurrences will be plotted as an attracter at corresponding period. I could find (1) groups of periodic events on about every 27 days though small number of events, (2) groups of periodic events with a few succeeding events, (3) groups of periodic events and events with a half periodicity, (4) groups of periodic events and events with changing periodicities, (5) groups of events with no clear periodicity. Category (1) is few, since I did not analyze groups with small number of events. (2) is similar to (1). Two groups identified as (3) with large number of events. Most of deep moonquake groups are categorized into (4). Some groups show shifting longer periodicity than before, some opposite. (5) includes almost random events. These categories could be found both for formally identified and newly identified deep moonquakes.

Eyeball inspection of similar waveforms of deep moonquakes may have restricted specially for good correlated seismograms. Category (1) formally identified groups are no longer but most of them are into (4) by the new catalogue. Category (5) could not have been found formally. Since the 114 formally identified deep moonquake foci are grouped into 77, it suggests that the focal region of deep moonquakes is much more large than about 1km formally we derived from the limited data.

Groups of increasing periodicities are located on the south-western side and those decreasing most of them on the north-eastern side. Both of them occurred when the earth libration was in the north-west to south-east direction. Deep moonquakes on the north-west side of the moon show increasing periodicity occurring the earth libration in the direction of north-east to south-west.

Provided that the longer observation period is available, number of seismic events would increase drastically, and categories of groups of (1), (2) and (3) may show similar periodicity of (4). Category (1) events used to be the main reason to derive the mechanism of (B) and (C), however, they are now identified as (4). Except for events of (5), the tidal effect on the deep moonquake occurrences is considered as the controlling factor similar to the A01 deep moonquakes which are strongly dependent on the earth-moon tide.