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Kaguya observations of the lunar wake in the terrestrial foreshock

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There forms a tenuous region behind the Moon in the solar wind, as the lunar dayside surface adsorbs most of the incident solar wind plasma. Entry processes of solar wind plasma into this tenuous region, which is called the lunar wake, have been widely studied. In addition to gradual refilling of the wake by the ambient solar wind, it has been known that a portion of solar wind protons that are scattered at the dayside surface or deflected by crustal magnetic fields can enter the wake (i.e. type-2 entry). However, proton entry into the deepest lunar wake (i.e. anti-subsolar region at low altitude) by the type-2 process needs specific solar wind conditions. Here we report, using data from Kaguya spacecraft in orbit around the Moon, that solar wind ions reflected at the terrestrial bow shock easily access the deepest lunar wake, when the Moon is located in the foreshock. This phenomenon is called type-3 entry. In one case, when the spacecraft location is magnetically connected to the lunar night-side surface, the kinetic energy of upward-going field-aligned electron beams decreases or electron beams disappear during type-3 entry events. This shows that the intrusion of the shock-reflected ions and electrons into the wake changes the electrostatic potential of the lunar night-side surface.