Latitudinal distributions of magnetic variations in the near-earth magnetosphere during substorm

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We examine the latitudinal distributions of magnetic variations in the near-earth magnetosphere during substorms by simultaneous magnetic observations of the first Quasi-Zenith Satellite (QZS-1) and the Engineering Test Satellite VIII (ETS-VIII). QZS-1, which has a unique orbit of quasi-zenith orbit with an inclination of 41º, an apogee of 7.1 Re radial distance, and an orbital period of 24 h, can stay for a long time in the near-earth magnetosphere away from the magnetic equator. ETS-VIII is a geosynchronous satellite located at the E146º longitude, which is within the QZS-1 longitude range. We selected 356 dipolarization events at ETS-VIII when the difference of magnetic local time between QZS-1 and ETS-VIII was less than 1 h.
Typical magnetic variations are classified into 5 types roughly depending on the magnetic latitude of QZS-1 (MLAT) as below:
(Type 1) In |MLAT|<~ 20º, QZS-1 naturally observed magnetic variations similar to those at ETS-VIII with a small delay (1–2 minutes).
(Type 2) In ~20º<|MLAT|<~30º, the onset of large magnetic excursions at QZS-1 was several tens of minutes delayed by the dipolarization onset at ETS-VIII. The excursions were not similar to those at ETS-VIII and were polarized in the azimuthal direction with large-amplitude oscillations.
(Type 3) In ~30º<|MLAT|<~50º, QZS-1 observed small magnetic excursions without oscillations. Surprisingly, the time delay between QZS-1 and ETS-VIII was only within 1–2 minutes.
(Type 4) In ~40º<|MLAT|<~50º, QZS-1 sometimes did not observe any variations.
(Type 2+3) Some events had both features of Type 2 and Type 3.

The large-magnetic excursion of type 2 events can be considered to be a direct crossing of the field-aligned currents (FACs). The large delay time corresponds to the poleward expanding time of the substorm currents system. The oscillations with the excursion may be caused by a small-scale structure of FACs. On the other hand, the small magnetic excursion of type 3 events can be considered to be a magnetic effect outside (polar side) the FACs. This is similar to the magnetic bay on the low-latitude ground, which is the magnetic effect inside (equator side) the FACs. We call the magnetic variation that we found “magnetospheric polar side bay”. If the intensity of the FAC is small or QZS-1 is far away from the FACs, any magnetic variations may not be observed at QZS-1, so the event was classified into type 4. The latitudinal distribution of polarization, amplitude, and delay time will be quantitively examined. Also, we will further investigate the relation among the magnetic variation away from the magnetic equator, plasma particles, and aurora, using the Arase satellite, which has a large inclination of 32º.

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