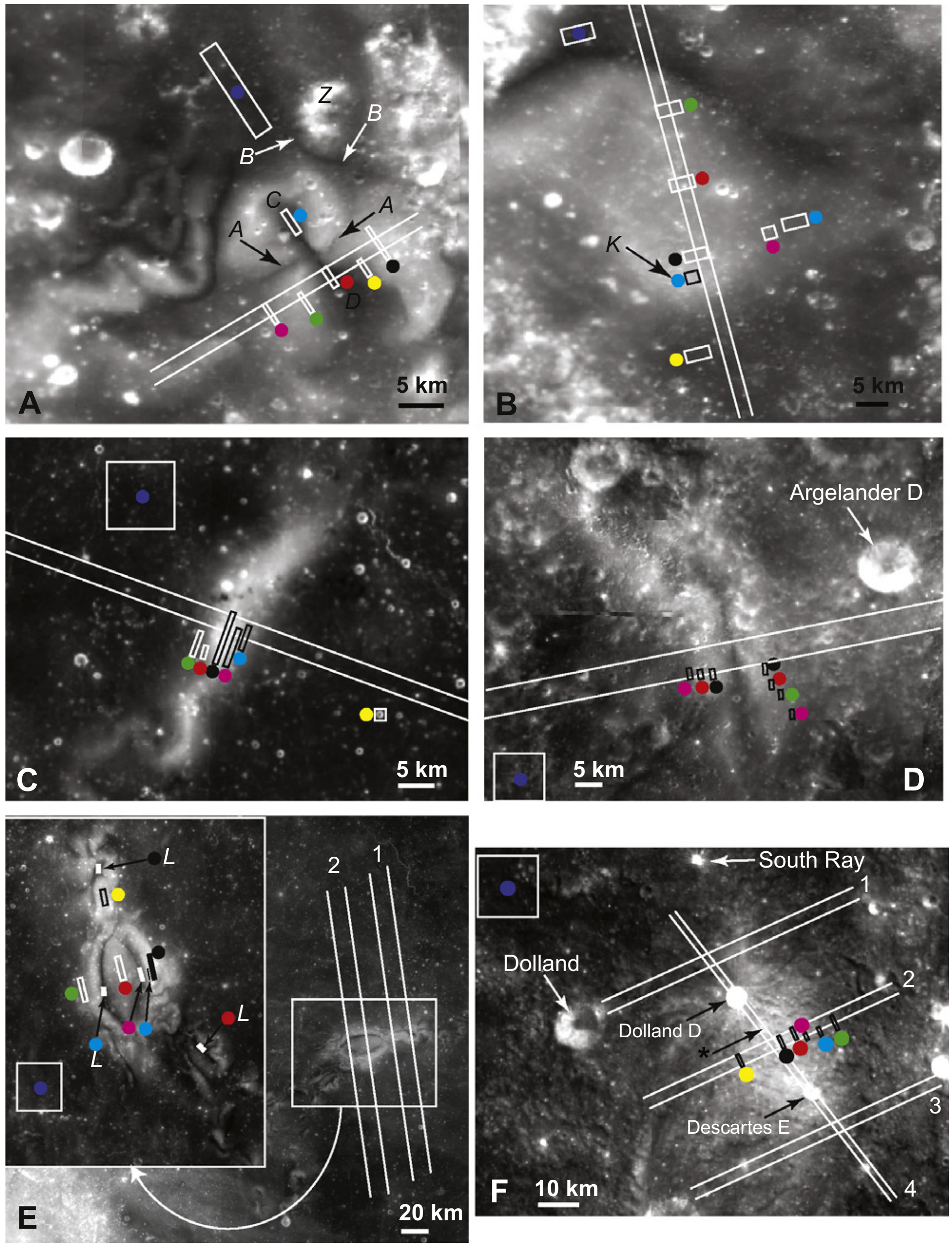

Fig. 2. Mare and highland lunar swirls (750 nm Clementine reflectance). White and black rectangles and their associated colored circles indicate regions where approximate band strength and albedo are plotted in Fig. 3. Rectangles with labels *K* and *L* in parts B and E, respectively, indicate regions with repeated colors. Areas between white lines have been averaged to generate the transects in Fig. 4. North is up. (A) Mare Ingenii (−33.6°S, 163.1°E), (B) Mare Ingenii, south of part A (−36.1°S, 165.4°E), (C) north of Reiner Gamma swirl (−10.7°S, 304.9°E), (D) west of Airy crater (−18.1°S, 3.4°E), (E) Reiner Gamma swirl (7.5°N, 301.5°E), (F) Descartes swirl (−17.1°S, 9.9°E), location marked with ∗ is shown in Fig. 4f.

alternative model that involves electric fields at swirls. Electric fields have been used to explain dust transport on asteroids (Berg, 1978; Hughes et al., 2008; Riner et al., 2008) and the Moon (Berg et al., 1976; Page and Carruthers, 1978; Rennilson and Criswell, 1974; Severnyi et al., 1975; Stubbs et al., 2006; Zook and McCoy, 1991; Zook et al., 1995). Electric fields are often produced by plasma interactions with magnetic fields (Alfvén and Fälthammer, 1963), such as in the Earth's aurora (Ergun et al., 2004; Hull et al., 2003; Raadu, 1989). Neugebauer (Neugebauer et al., 1972) was the first to infer that electric fields are produced by lunar crustal magnetic anomalies, and the process is also discussed in Hood and Schubert (1980) and Hood and Williams (1989).

3.1. Charge separation at magnetic anomalies

When solar wind protons and electrons encounter a weak crustal magnetic field, some electrons are reflected before reaching the surface due to the magnetic mirroring effect, assuming the frequency of the magnetic field change is less than the electron gyrofrequency (adiabatic assumption) (Lin, 1979; Lin et al., 1998). For example, surface fields of 1–5 nT reflect of ∼25–50% incident electrons (Halekas et al., 2001) (most swirls have fields of >1 nT at 20–30 km altitude (Hood et al., 2001; Blewett et al., 2005a,b)). However, the more massive and slower solar wind protons have a lower gyrofrequency, and their less adiabatic motion will cause them to more deeply penetrate the magnetic field. The differential