



Figure 2 | Local distribution of olivine-rich sites around various basins or maria. The background map is the surface topography obtained by the Kaguya mission²⁸. The larger rectangles and smaller circles indicate olivine-rich points with multiple and single SP detections, respectively. Photos A1, B2, C1, D1, E1 and F1 are close-up images of olivine-rich sites taken by the MI or the TC onboard Kaguya^{14,15}. On the close-up images, olivine-rich points are plotted as red rectangles with white 5 km scale bars. The accompanying plots show the continuum-removed reflectance spectra R_c at the location of the yellow square marked on each close-up image.

In Fig. 1 we plot 245 olivine-rich points on a lunar crustal thickness map obtained by Kaguya¹³. Most of the olivine-rich points are grouped into several local sites. For example, SP detected 59 in the Copernicus crater and 4 in the Aristarchus crater. Taking into account the local geologic context, based on images obtained by Kaguya's Multiband Imager (MI) or Terrain Camera (TC) during the SP observation^{14,15}, we found that most of the localities having multiple olivine-rich points are associated with small fresh craters (Fig. 2). Therefore, we divided and assigned the 245 olivine-rich points to 34 olivine-rich sites (Supplementary Table S1). The representative spectra for the individual olivine-rich sites are shown in Supplementary Figs S1–S3.

Figure 1 shows that most of the olivine-rich sites are located around impact basins: that is, (A) Mare Moscoviense, (B) Crisium, (C) Imbrium, (D) Humorum, the SPA basin ((E) Schrödinger and (M) Zeeman craters), (G) Nectaris, (H) Serenitatis, (I) Humboldtianum and (J) Australe. These basins are located on

thinner crusts with a thickness of about 30–50 km. Most of the olivine-rich sites are concentrated on the lunar nearside. Whereas there is no olivine-rich site in the Feldspathic Highlands Terrane¹⁶, olivine-rich sites are found in the SPA and Moscoviense, on the far side, in locations where the crust is thin.

Furthermore, in the vicinity of each basin, olivine-rich sites are distributed along the concentric region of the basin. For example, Fig. 2a shows that olivine-rich sites are distributed along the rim of Moscoviense, whereas there is no olivine-rich site in the central region of the mare or regions far from the outer ring. Another conspicuous example is Crisium, where the olivine-rich sites are limited to a narrow concentric region around the mare (Fig. 2b). Around Imbrium (Fig. 2c) we found olivine-rich sites in the Copernicus (C1), Eratosthenes (C3), Aristarchus (C6), the Montes Alpes (C2) and the terrace in the Sinus Iridum (C4 and C5). Their locations seem to correspond to the prominent rings of Imbrium¹⁷. In the SPA (Fig. 2e), there are two craters with olivine-rich sites