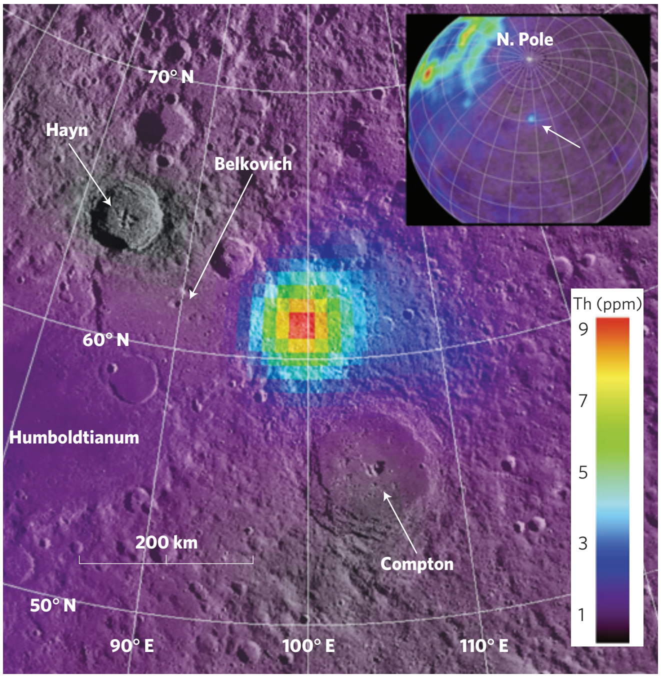


**Figure 1 | Compton–Belkovich thorium anomaly.** The location of the CBTA is northeast of Humboldtianum basin and just beyond the Moon's eastern limb (LP-GRS 0.5°, ~15 km resolution Th data[1,2] as deconvolved by Lawrence *et al.*[3], overlain on WAC 400 m per pixel base). The highest measured Th intensity corresponds to a concentration at this resolution of ~10 ppm at the centre of the Th hotspot.

## Domes and irregular depressions

The elevated terrain is highest on the western and eastern flanks, reaching −1,800 m elevation, about 300–400 m above the central region (Fig. 3c, profile b–b′). In the north, at the edge of the high-reflectance terrain and CBF topographic feature, is an isolated massif over 6 km across at its base and nearly a kilometre high from base to summit. Its morphology suggests that it is volcanic in origin; its upper slopes range from 20 to 26° and it has a summit plateau with a broad, central depression (Fig. 4).

Just north-northeast of the CBF central depression, a north–south-oriented elongate rock body occurs with moderate relief (7°–22° slopes and 200 m above the base elevation, Fig. 2b). This feature, 2.5 km in length and ~2 km wide at its base, is probably also a volcanic construct (see also Fig. 4, 'middle dome'), but smaller than the massif ('big dome') to the north. Small channel-like features suggest flows and erosion occurred on its west side. Clusters of 1–5 m boulders are concentrated in several locations along its crest and flanks.

In and around the central area of the irregular depression marked '1' in Fig. 2b,c, small domes are also observed (for example, Fig. 2d). A half dozen small domes occur in the central area—all with similar size (~500 m across), but different morphologies, including some elongate forms and some that are subtle, low-relief bulges. Most have a prominent clustering of boulders at their summits and on their flanks (for example, Fig. 2e). The boulders are typically one to several metres in size, but some are as large as 10 m. Such clustering of boulders on domes has been noted in other locations, such as the Marius Hills[9]. The boulders suggest weathering of coherent rock as the domes degraded over time, with the largest boulders having been excavated by small impacts. In the example shown in Fig. 2d, the dome is ~500 m in diameter at the base and ~100 m high. The shape of the dome and its flank slopes, ~20°, indicate a more viscous lava composition (silicic) than expected for volcanic constructs associated with low-viscosity mare basalt lavas, which typically have slopes of <7° (ref. 10). Small domes such as these are found on Earth, associated with silicic (for example, rhyolitic) volcanism.

In addition to light-toned materials, numerous scarp-bounded irregular depressions occur in the CBF (Fig. 2b,d). Some of the irregular depressions form arcuate patterns (for example, Fig. 2c), although the central depression is not circular, and impact craters disrupt the boundary of the depression. In the irregular-shaped, central depressed area of the CBF, vertical relief on some of the scarps bounding collapse structures is ~50–100 m.

Bright material extends some 7 km to the E-SE beyond the region of elevated topography. Dispersal of bright material could be caused by impact cratering, and 7 km is a reasonable length scale for mixing from small impacts[11]. Another possibility is dispersal by pyroclastic eruption. The centre of a circle that fits the outline of this extension of bright material would be located in the depressed area labelled '3' in Fig. 2b, possibly a source vent. However, the high viscosity of this silicic magma may have favoured effusive eruption over pyroclastic eruption.

## Possible rock types of the CBF

Using LP–GRS FeO and Th data, we investigate possible rock types that may be exposed in the CBF. Taking the low-altitude, two-degree binned data, a plot of FeO versus Th for the feature and surrounding regions shows the anomaly extending to about 3 ppm Th at about 5 wt.% FeO (refs 4,12; Fig. 5). The gamma-ray response function is broad (integrating the signal over a radius ~80 km, with a full-width half-maximum of 48 km for 30-km-altitude data[2]) such that the observed signal probably corresponds to a higher Th concentration and more focused areal extent than indicated by the first-reported data, as described by Lawrence and colleagues[2,3]. Lawrence *et al.*[2] modelled the CBTA as a highly localized source of high-Th material and concluded that the concentration of Th in the source materials at the centre of the CBTA could be as high as 40–55 ppm.

In Fig. 5, the LP–GRS data project toward high Th along vectors pointing to the compositions of two lunar rock types that are rare in the lunar sample collection: (1) granite or its fine-grained equivalent, felsite (rhyolite), and (2) the more mafic alkali norite or alkali gabbro (monzogabbro). These rock types are known only as small rocks and clasts in breccia, mainly in Apollo 12, 14, and 15 samples[13–18]. A pristine granitic rock fragment from Apollo 12 regolith[19,20] has the highest Th concentration measured so far in a lunar rock, 61 ppm, and an FeO concentration of 5 wt.%. Other lunar granites, however, have similarly enriched Th concentrations, typically in the 40–60 ppm range. The more mafic alkali-suite rocks also have elevated Th, but lower concentrations, for example, 10–40 ppm (refs 17,21). Alkali anorthosite could also be associated with these rocks, but typically has lower Th concentrations (Fig. 5). On the basis of compositions, silica- and feldspar-rich rocks would contribute to the high reflectance of the anomaly, especially granite or its extrusive equivalent, rhyolite.

Data from the LRO Diviner Lunar Radiometer[22] contribute another piece to the puzzle. The spectral signature measured by Diviner's three ~8-μm channels is consistent with highly polymerized mineralogy such as silica and/or alkali feldspar[23,24]. Quartz and K-feldspar are the two main mineralogical components of lunar granite, and no other common lunar minerals (olivine, pyroxene, anorthitic plagioclase, ilmenite, spinel) would create a similar signature in the Diviner data. An overlay of Diviner modelled Christiansen feature (CF) position in the 7.1–8.6 μm region (Fig. 6), which correlates inversely with silicate polymerization, shows a close correspondence between low CF modelled wavelength and the area of high reflectance. The CF modelled data demonstrate a better areal correspondence with the high-reflectance feature than with the topographic expression of the CBF. This observation supports