earlier earthquakes, such as a magnitude 6.6 earthquake in September 1998 that struck about 100 km closer to the Lusi volcano, not do the deed? This earlier earthquake could, of course, have primed the Lusi system for eruption, leaving the 6.3 Yogyakarta earthquake to finally kick the system into failure. But Davies and colleagues suggest that the probability of such a scenario is quite low.

Davies and colleagues estimate the static and dynamic stress changes that the 6.3 Yogyakarta earthquake generated at the site of the Lusi eruption. They find that the dynamic stresses are similar to what can be generated from the force of an adult footstep, whereas the static stress changes are about 500 times smaller than that. The nearby drilling, on the other hand, generated drill-pipe pressures capable of causing stress changes similar to the pressure generated by about 10 to 20 elephants, all balancing on a single stool. Intuitively, these larger stress changes would be the more probable trigger of the eruption, which is what Davies and colleagues conclude. But there is no way to be absolutely certain because we are restricted to using primarily surface measurements to infer what is going on in a complex system at depth.

It is likely that there is a temporal and spatial aspect to setting a mud volcano off that induces variability in the potential triggering threshold, rendering it difficult to quantify. High-tech monitoring of the daily discharges of multiple mud volcano systems might be the best way to provide site-specific constraints and improve our understanding. Such monitoring would help establish what the recharge rates are, and whether there are connections between nearby systems. Large eruptions could require a healing period — during which recharge occurs — before another eruption can occur, thus raising the triggering threshold.

Davies and colleagues provide the best guess of Lusi's causes, under the current constraints of data availability. Better technological tools will hopefully provide a clearer picture when the next eruption occurs.

References

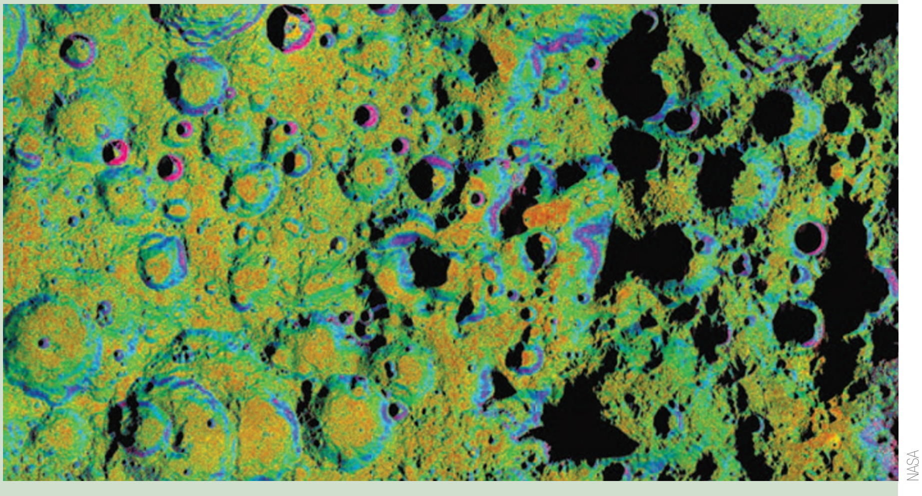
1. Mazzini, A. *et al. Earth Planet. Sci. Lett.* **261,** 375–388 (2007).
2. Manga, M. & Brodksy, E. E. *Ann. Rev. Earth Planet. Sci.* **34,** 263–291 (2006).
3. Mellors, R., Kilb, D., Aliyeev, A., Gasanov, A. & Yetirmishli, G. J. *Geophys. Res.* **112,** doi:10.1029/2006JB004489 (2007).
4. Wang, C.-Y., Wong, A., Dreger, D. S. & Manga, M. *Bull. Seis. Soc. Am.* **96,** 355–363 (2006).
5. Davies, R. J., Swarbrick, R. E., Evans, R. J. & Huuse, M. *GSA Today* **17,** 4–9 (2007).
6. Tingay, M., Heidbach, O., Davies, R. & Swarbrick, R. *Geology* **36,** 639–642 (2008).
7. Davies, R. J. *et al. Earth Planet. Sci. Lett.* doi: 10.1016/j.epsl.2008.05.029 (2008).
8. Cyranoski, D. *Nature* **445,** 812–815 (2007).

PLANETARY SCIENCE

Shackleton grows older

With the regular dispatch of new probes and spacecraft to exotic far-away planets and moons, Earth's own Moon isn't the locus of our fascination that it once was. Yet, as a recent report of substantial water in the Moon's mantle suggests, Earth's nearest neighbour hasn't revealed all its secrets. It is, after all, a body that perpetually hides one of its halves from our view.

Because of the way the Moon is tilted on its axis, its south polar region receives sunlight at a low angle, which makes it difficult to obtain information about this heavily cratered terrain. However, data returned by the recent SMART-1 mission as well as radar data from Earth-based antennae offer a fresh perspective. Paul Spudis from the Lunar and Planetary Institute, Houston, and colleagues used these data to re-evaluate the geology and age of the Shackleton Crater (*Geophys. Res. Lett*, **35,** L14201; 2008).



NASA

The 20-km-wide crater straddles the lunar south pole, and as a result it has received a fair bit of attention. Because is almost always in the shadows, it is also likely to be much cooler than other regions on the Moon's surface. It may therefore act as a potential trap for volatiles, such as water carried by meteorites. But a key to the crater's potential for gathering water is its age — a relatively young crater would not be expected to trap a significant quantity of volatiles.

Previous work on the morphological attributes of Shackleton Crater suggested that it formed ~1 billion years ago and is thus a young feature (in the eyes of planetary scientists). Using their high-resolution data, Spudis and colleagues tested this assessment by making a fresh estimate of the crater's age: they looked at the density of secondary craters that had been dug into material ejected when Shackleton Crater formed. The higher the number of these craters, the older the Shackleton Crater must be.

Comparing the density of secondary craters around Shackleton Crater with that on the Moon's surface where the absolute ages are known, they came up with a crater formation date a little more than 3.5 billion years ago, much older than previously thought. The relatively fresh appearance of Shackleton Crater may have more to do with the low angle at which sunlight illuminates it rather than its age.

Shackleton Crater appears to have been around for long enough to accumulate volatiles, which might prove to be an asset if long-term human settlement on the Moon is ever planned.

Ninad Bondre