Mistastin Lake Crater, Labrador, as a Lunar Analogue Site

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Introduction

On the Moon – one of the highest priority targets for the Canadian and international space communities – meteorite impact craters are the dominant geological landform. Key sites of scientific and exploration interest for early return missions to the Moon lie in the South Pole Aiken basin, a region dominated by anorthositic rocks. Geological relationships between specific craters and their impactites (i.e., rocks affected by impact events) on the Moon are very poorly constrained.

Theory and Methods

The best analogue sites on Earth, which are similar to South Pole lunar craters, are impact structures developed in anorthositic target materials, with preserved impactites of similar lunar mineralogy and outcrop characteristics. Typically, impact ejecta deposits are rare on Earth due to post-impact erosional processes, therefore, finding an appropriate analogue site for comparative studies is difficult.

The Mistastin Lake crater, in northern Labrador, Canada (55°53'N; 63°18'W) represents an unparalleled lunar analogue site which includes both an anorthositic target and preserved ejecta deposits. This intermediate-size crater (28 km diameter) formed by a meteorite impact ~36 million years ago, and still exhibits a distinct rim and central uplift. It is comparable to many of the larger impact craters on the Moon (150-200 km in diameter) when scaled for gravity differences. The target rocks at Mistastin consist of anorthosite, mangerite and granodiorite. A suite of impactites include: shocked and/or fractured target rocks, monomict breccia, polymict lithic breccia, impact melt-bearing breccia ("suevite") and impact melt rocks.

An initial 10-day reconnaissance investigation of the Mistastin Lake crater was carried out in September, 2009. Detailed field studies primarily focussed on the banks of creeks where contact relationships between units are best exposed.

Examples

Some preliminary examples of geological lunar analogues at Mistastin Lake include:

1) Anorthosite in a variety of impact settings (i.e., shock levels): as shocked rocks in the central uplift, low-shock lithic (i.e., melt-free) impact breccias, and as clasts within the high-temperature impact melt sheet.
2) An exceptional ~80 m thick unit of impact melt rock within the crater rim.
3) Impact melt-bearing breccias ("suevites"): rock with fine-grained light grey matrix with abundant plagioclase clasts and inclusions of melt fragments.
4) Impact ejecta deposits inside the crater rim and overlain by impact melt rock, analogous to "double layer ejecta" craters on the Moon in which impact melt overlie the blocky ejecta blanket.

The discovery of impact ejecta deposits at Mistastin are particularly important. While they lie within the rim of the original crater, they lie outside the initial transient crater and are, therefore, by definition ejecta. Ejecta deposits are only preserved at one other Canadian impact crater – the Haughton impact structure, Devon Island (Osinski et al. 2005) – so the Mistastin outcrops provide an important new site at which to understand the origin and emplacement of impact ejecta.

Conclusions

Impact cratering is considered the most important surface process on the Moon. With limited lunar samples, planetary scientists look to terrestrial craters for comparative studies. The Mistastin Lake Crater, Labrador offers a unique opportunity to understand the effects of shock on impacted materials; and to understand the origin and emplacement of impact ejecta.

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References

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