LONGEVITY OF IMPACT-INDUCED FAULTS AS PREFERRED SITES FOR LATER TECTONIC ACTIVITY: A FURTHER TERRESTRIAL TEST. Sean C. Solomon and Linda Meinke, Department of Earth, Atmospheric, and Planetary Sciences, Massachusetts Institute of Technology, Cambridge, MA 02139.

Introduction. The hypothesis that impact-induced faults have been preferred sites for later deformation in response to lithospheric stresses has been suggested for several planets and satellites [e.g., 1-3]. We recently investigated this hypothesis on Earth by examining whether terrestrial impact structures show higher rates of nearby earthquake activity than do surrounding intraplate regions [4]. For 28 of 30 probable impact structures having an original crater 20 km or more in diameter and ages of 3-2000 m.y. [5], we found that rates of nearby seismicity have been no higher than the regional background rates. For two large probable impact structures, Vredefort and Charlevoix, with higher than normal rates of nearby seismicity, factors other than slip on impact-induced faults appear to control the occurrence of earthquakes [6,7]. On the basis of these results, we concluded that impact-induced faults, at least on Earth, do not persist as lithospheric "weak zones" for periods in excess of several million years after the impact event.

One difficulty with generalizing from these findings to other planets and satellites however, is that most of the large terrestrial impact structures are deeply eroded. Because many impact-induced faults are of shallow extent, particularly outside the crater rim [e.g., 8-9], a significant fraction of the faults produced during the formation of older craters on terrestrial continents may no longer be preserved. Such would not be the case, however, for an impact on the continental shelf, where the post-impact environment should have been generally one of subsidence and sediment deposition [e.g., 10]. The recent discovery of the Montagnais impact structure on the continental shelf southeast of Nova Scotia [11] offers an opportunity to search for an association of recent seismicity with an impact structure not significantly affected by post-impact erosion.

The Montagnais Impact Structure. The Montagnais structure, located in 100-m-deep water near the outer edge of the continental shelf (Fig. 1), is a complex crater at least 45 km in diameter [11]. The structure has been well elucidated by multichannel seismic reflection profiling and by a drill hole that penetrated the central peak complex to the rocks of the Paleozoic basement; the basal impact melt sheet yields K-Ar ages of 50-55 m.y. [11]. Except for some localized erosion around the crater periphery attributed to back flow of sea water immediately following the impact [11], the crater and its subsurface structure are generally well preserved.

We have searched seismicity catalogues for earthquakes in this century having epicenters in the vicinity of the Montagnais structure. The catalogues of Gutenberg and Richter [12] and Rothé [13] list no earthquakes within about 5° of the center of the impact stucture for the periods 1904-1952 and 1953-1965, respectively. The Bulletins of the International Seismological Center (ISC) list no earthquakes within one crater diameter of the center of the impact structure during the 21-year interval 1964-1984; only 4 events occurred within 5 crater diameters during this period (Fig. 1), all of very small magnitude. These rates of earthquake activity per area are not significantly different from that of the regional background.

Despite the low level of seismicity in the region of the Montagnais impact structure, the lithosphere beneath the continental shelves of eastern North America is subject to stress in response to deglaciation of the continent [14], sedimentary loading of the shelf [15], lateral variations in elevation and crustal thickness [16], and plate tectonic driving forces [17]. The resultant stress field has given rise to a number of large earthquakes along the eastern Canadian continental margin, the largest of which was the M = 7.2 Grand Banks earthquake of 18 November 1929 [18], located about 6° east-northeast of the Montagnais structure. The impact-induced faults of the Montagnais impact structure, therefore, do not appear to be acting as preferred sites of stress release on the Canadian continental shelf.

Conclusions. The 45-km diameter Montagnais structure provides another example to support the conclusion that modern intraplate seismicity does not show any general correlation with impact-induced faults associated with the largest terrestrial impact structures [4]. This new example is a particularly important one because of the likelihood that none of the faults formed during the impact have subsequently been removed by erosion. Terrestrial analogs thus continue to offer little support for the hypothesis that impact-induced fractures remain preferred sites for the release of lithospheric stress for periods in excess of several million years after the impact event.

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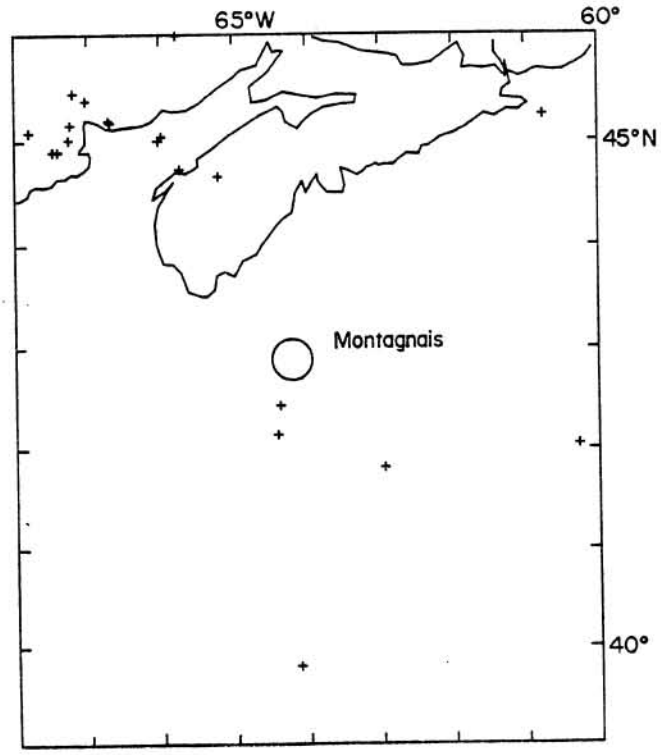

Fig. 1. Recent seismicity in the vicinity of the Montagnais impact structure. Earthquake epicenters (crosses) are from the ISC for the inclusive years 1964-1984. The approximate outline of the impact structure is from [11]. The coastline is also shown. Mercator projection.