(i) The recently described semi-circular Charlevoix structure (Rondot, 1968), lies along the north shore of the St. Lawrence river between Baie St. Paul and La Malbaie, Quebec. The rocks within the structure include Precambrian metasedimentary gneisses, anorthosite, charnockitic rocks, granodiorite, granite, and Ordovician sedimentary rocks including sandstones, limestones, and shales. Six samples, taken in pairs, from the Ordovician (Trenton?) limestone within the structure and a pair of samples of Trenton limestone from outside the structure were collected by E. H. Chown. Data was obtained for the total natural emission (kE), the peak amplitude (Pk_2), and the total emission from x-ray excited low temperature peak. One of the peaks (Pk_1) could not always be satisfactorily resolved, so that the values for the peak ratio (Pk_2/Pk_1) are only approximations. Figure 2 shows the spread of values from each collection site and the general tendency for a decrease towards the center of the structure. For the radiation-induced peak in particular, this decrease suggests that there has been a progressive distruction of a solid-state characteristic with increasing levels of shock.

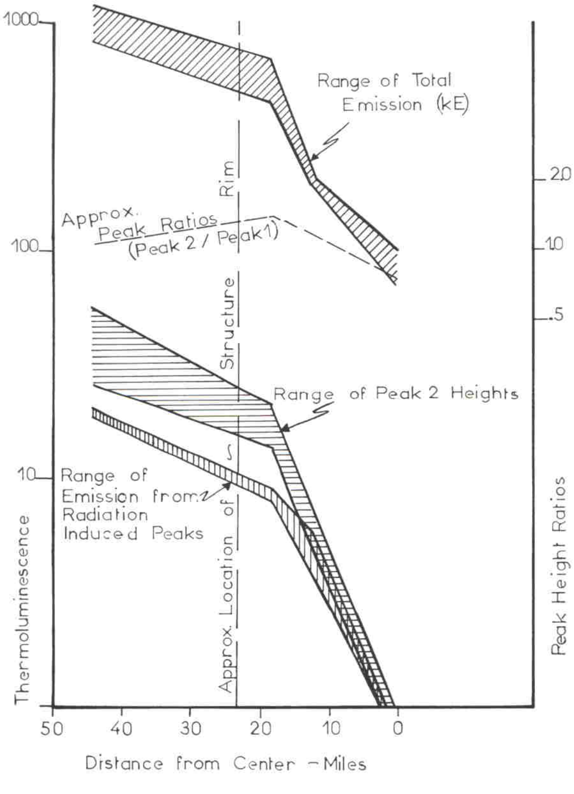

FIG. 2. Variation in thermoluminescence parameters in vicinity of meteorite "crater" (0 miles at crater center).

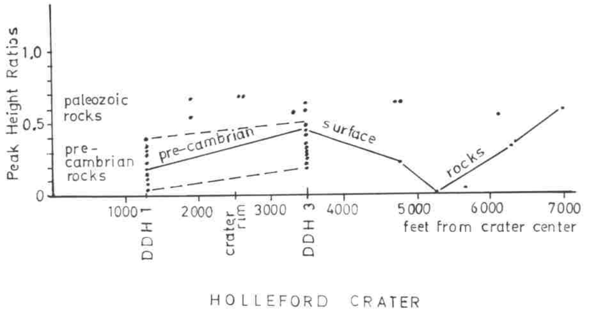

FIG. 3. Thermoluminescence peak height ratio in the vicinity of meteorite "crater" (0 feet at crater center).

(ii) The Holleford structure is located about 17 miles northwest of Kingston, Ontario. The present topographic surface is a basin about 5000 feet in diameter in which there are saucer-shaped beds of limestones which are not found outside the basin. Underlying these there is a sequence of buff and grey limestones with some shale; and basal beds of red and green shales, green calcareous arkose, greywackes, and conglomerates. These beds are middle Ordovician and rest unconformably on upper Cambrian (Potsdam) sandstones, or Precambrian marbles, quartzites, and gneisses. Drilling has shown that within the basin, the undeformed sediments overlie a polymict breccia of fragments of Precambrian rocks in a fine grained matrix. Similar breccias are not exposed in the Precambrian rocks outside the structure (Gold, 1964).

Sixteen samples of Precambrian marbles and Paleozoic limestones and calcareous sandstones were collected by the senior author from surface outcrops in and near the basin. Twenty-one samples of Paleozoic limestones and Precambrian marbles from a diamond drill hole (DDH 3) outside the basin rim and thirty-one samples of Paleozoic limestones, Precambrian gneisses and polymict breccia from a diamond drill hole (DDH 1) were supplied by D. P. Gold. Figure 3 illustrates the variations of the Pk_2/Pk_1 ratio of samples of the Paleozoic and Precambrian rocks at increasing distances away from the basin center. The ratios for most of the Paleozoic samples are rather uniformly between 0.7 and 0.5, while most of the Precambrian samples are less than 0.5. The low ratios for most of the Precambrian samples suggest high levels of strain. A possible explanation for the low ratios in some of the Paleozoic sedimentary rocks (DDH 1) is that they are derived in part from the strained Precambrian rocks.

(iii) The Brent structure in the upper Ottawa valley, Ontario, is a "super-imposed circular structure, some 10,000 feet across, in alamandine–amphibolite facies quartzo–feldspathic gneiss of Grenville (Precambrian) age. A bowl-shaped structure underlain by a pod of breccia and shattered country rock has been delinated by drilling" (Gold, 1966). Forty-two outcrop samples from an area south and east of the structure were provided by D. P. Gold. The amplitudes of the single peak glow curves from these samples were generally low with some higher values. There is an apparent tendency for the higher values to be arranged in two zones, roughly concentric to the structure rim. The first high zone is about 500 feet from the rim, while the second varies in distance from the rim from about 2000 feet on the east to about 3500 feet on the south. The more common low values appear to be in accord with the usual effects of high levels of shock, but the higher values cannot be explained on this basis. An alternative explanation, which is not related to shock, can be found in the observation that thermoluminescence should be high in the greenschist and granulite facies and low in the almandine–amphibolite facies. (McDougall, 1970)

NUCLEAR EXPLOSIONS

Glow curves from twelve samples of quartzite and granodiorite from the vicinity of the Sedan nuclear crater, Nevada Test Site, which were supplied by N. M. Short, are illustrated in Figure 4. The glow curves are numbered on an arbitrary scale of increasing shock based on increasing amounts of isotropized quartz and glassy material (zero indicates unshocked samples). In general, the shocked samples are less thermoluminescent than the unshocked samples. Examination of the glow curves from the quartzites shows that with increasing shock: (a) the level of thermoluminescence does not decrease uniformly; (b) the shape of the curves changes non-uniformly; (c) there is no systematic increase in individual peak amplitude which might be ascribed to radioactivity from the nuclear explosion; (d) there is apparently no systematic change in the peak ratio which can be ascribed to either low level strain or heating; and (e) the decrease in thermoluminescence is not the same as the decrease due to crushing. A very recent study of the quartzites has shown that with increasing shock, peaks due to artificial irradiation decrease uniformly and the thermal activation energy of these peaks increases fairly uniformly (Manconi and McDougall, 1970).

CRUSHING EFFECT

The decrease in thermoluminescence due to decreasing grain size is principally due to increased light scattering and absorption by fine particles (Fornaca-Rinaldi and Tongiorgi, 1961). This effect is illustrated in Figure 4 for unshocked quartzite from the vicinity of the Sedan nuclear crater; syenite from Brome Mountain, Quebec; and high purity limestone from Bedford, Quebec. In each case the effect of decreased grain size has been to reduce the amplitude of the glow curves with virtually no change in the peak ratios or the position of the peaks. Further reduction in size by a few minutes of hand grinding of the finest fraction caused a further reduction in the glow curves. Both Fornaca-Rinaldi and Tongiorgi, (1961) and Lewis (1968) have observed increases in emission from specific peaks due to fine grinding, but this effect was not detectable in any of this group of samples. Except as noted above, the reduction in size of the particles was accomplished with a laboratory jaw crusher and it is believed that this treatment inhibits the formation of lattice dislocations during communution. The justification for this belief lies in the observation that very few dislocations are formed in Iceland spar if it is cleaved quickly (Gilman and Johnston, 1957).

ARTIFICIAL STATIC LOADING

Artificially deformed carbonate rocks usually show an initial increase in thermoluminescence after they have been subjected to low strain followed by a reduction in thermoluminescence at higher strain (Angino, 1964; Morency and McDougall, 1964; d'Albissin and Fornaca-Rinaldi, 1968). However, triaxial loading of machined samples of limestone from Bedford, Quebec, and syenite from Brome Mountain, Quebec, at axial load increments of 1000 psi, and several comparatively low confining pressures, resulted in a cyclical variation in thermoluminescence, with apparently no real change in thermoluminescence over the ranges tested. At the same time, direct comparisons of the variations of thermoluminescence with stress-strain curves, suggested but did not prove that the