scatter is only a ten-thousandth of that of the main beam, this still corresponds to a height of more than half a mile before the dose rate falls below that considered effective to attract the lightning strike to the source.

Many industries use radioactive sources giving local dose rates far in excess of 6×10^{-5} mr./h, and indeed I am aware of such a source used as a density gauge mounted on the upper section of an outdoor chemical plant synthesizing highly inflammable and explosive liquids.

In view of the foregoing, one would expect frequent reports of radiotherapy centres, industrial radiography departments, etc., being damaged by lightning; in fact, the search for reports of such occurrences has revealed only a vague rumour of this having happened once to a radiotherapy centre in the United States.

Must one therefore conclude that: (*a*) small sources of ionizing radiation are not effective as lightning attractors? or, (*b*) radiotherapy centres, etc., rarely operate during thunderstorms, and have, so far, been very fortunate?

This is a question to which some answer must be found, as at present neither of the two logical alternatives is satisfactory: either buildings 'protected' by these radioactive devices are in fact not actually protected and may well suffer lightning damage; or, sooner or later, a radiation beam will attract a lightning strike to the source of a tele-isotope unit and, unless this is as effectively earthed as a proper lightning conductor, the effects could be catastrophic. Energies of more than 5×10^{10} watts are usually involved and, apart from structural damage and the possible rupture of the sealed radioactive source, with resultant contamination, one hesitates to contemplate the fate of the unfortunate patient undergoing treatment.

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[1] Thunderstorm Census Organization (personal communications).
[2] Schonland, Sir Basil, *The Flight of Thunderbolts* (Clarendon Press, 1950).

GEOLOGY

Observations on the Mont Pelée Eruption of 1902 and their Significance to Ordovician Welded Tuffs of County Mayo, Eire

DURING recent investigation of some welded tuffs in the Ordovician rocks of eastern Murrisk, County Mayo, lenses of sillar, non-welded material were encountered at the base of the tuff-horizons. Similar layers had previously been reported by Stanton[1] and Dewey[2] during investigations farther west. Stanton[1] interpreted the variation in thickness of the sillar material as due to differences in the depth of sea-water present before the tuff built up to sea-level, prior to it becoming a truly welded tuff. The entire process was regarded as a 'continuous whole'.

A letter written by the British Consul in St. Pierre on May 3, 1902, some five days before the Peléan eruption which destroyed the town and its inhabitants, has been brought to my attention by Mr. R. A. Japp, of Dundee, together with samples of the early ashes produced during the eruption. With permission, an extract from this letter is relevant:

"I wrote you about the volcano smoking last week. Yesterday afternoon it began to throw out enormous clouds of steam and black smoke from a different place.

"About one this morning I was awakened by a roaring noise, something like thunder and lightning. . . . The houses and street were covered with dust . . . white, as if there had been a snow-storm.

"The dust continued to fall until there was a layer of ¼ inch, and is still falling a little. It is all very fine (I enclose sample), and as we have no glass, but only 'jalousie' windows, it drives in and penetrates everywhere . . .

"The volcano is 4 miles from here. A river running from it was swollen with dirty water and mud, and made a great stink . . . Today the smoke and dust have spread—some of the latter having gone beyond Fort de France—20 miles away. I believe there will be no danger . . ."

The sample referred to has now been examined and found to consist principally of a very fine siliceous ash, in which occur broken and angular fragments (up to 0·05 mm in diameter) of crystals of quartz and labradorite feldspar. The labradorite (An_{55-70}) shows both multiple albite twinning and complex oscillatory zoning in which outer zones have sometimes been partly torn from the cores of the crystals. Some magnetite is present, but there are no recognizable shards in this very fine-grained, yellow-green tuff.

This account is of two-fold significance. First, it directs attention to the importance of the preliminary phases of eruption which precede the extrusion and accumulation of Peléan tuffs. Secondly, it indicates that the sillar bases to welded tuffs need not be strictly contemporaneous with the overlying welded material. MacGregor[3] and others have pointed out that the terms 'Peléan' and 'welded' tuffs are not necessarily synonymous.

The observation that the nearby rivers were swollen with debris from the early fall-out of ash shows that the loose ashes were rapidly transported to the sea. In areas where shallow water bordered the land, this fine ash would have been rapidly redistributed and deposited on the sea floor. Protracted activity of this type enables appreciable accumulations to develop before the extrusion of the main mass of pyroclastic material. The preliminary phases of such eruptions, therefore, may be responsible for the shallowing of the sea, so that the hot ash falling into the shallow water rapidly builds above water-level, so permitting welding to occur above the non-welded, non-contemporaneous base.

The welded tuffs of western Mayo show non-welded sillar bases in various places. In western Murrisk both Stanton[1] and Dewey[2] have recorded sillar layers in *MT*1 and *MT*2. In eastern Murrisk neither of these tuff layers has a continuous sillar base. Thin lenses are present on *MT*1, but the base of *MT*5 has a 4-ft.-thick layer of sillar material in the cliffs to the west of Lough Glenawough. No sillar material is present east of the lake.

The lowermost part of the sillar layer is almost devoid of shards. In places it consists of very fine dust with a few grains of quartz, which show uniform extinction. In the upper part of the sillar layer angular fragments of untwinned plagioclase An_{25-40} are abundant in the tuff, with less frequent angular quartz grains, a few of which show the deep embayments so common in the quartz grains of the overlying, welded tuffs. Virtually all the feldspar fragments are deeply altered to sericitic material, with the result that they are distinguished with difficulty from the intratelluric material, in which minute undeformed shards are present.

With the change from non-welded to welded tuffs there is an increase in the size of the shards, from 0·01 to 0·04 mm to 0·05 to 0·20 mm. There is an accompanying change in the proportion of included lithic fragments (0·2–3·5 per cent). These two factors may result from changes in the strength of the forces active at different stages of the eruption. Large shards are to be expected from the fully frothing pyroclastic flows, whereas smaller ones result from quieter, less spectacular eruptions of the early phases.

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[1] Stanton, W. I., *Quart. J. Geol. Soc. Lond.*, **116**, 269 (1960).
[2] Dewey, J. F., *Quart. J. Geol. Soc. Lond.*, **119**, 313 (1963).
[3] MacGregor, A. G., *Nature*, **157**, 305 (1946).