ROCK BURST RESEARCH AT LAKE SHORE MINES
KIRKLAND LAKE, ONTARIO

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On December 27, 1938, a violent rock burst took place at Lake Shore Mines, Kirkland Lake. Although this disturbance occurred about 280 miles from Ottawa, it was well recorded with phase differentiation on the vertical, short-period Benioff at Ottawa with markedly greater energy than was a blast of 40,000 lbs. of dynamite near New Haven at a distance but slightly greater (315 mi.) The shock originated, in the former case, at a depth of nearly 2700 ft. and, in the latter, at the surface. (Fig. A) Although the variations in conditions preclude any accurate deductions as to the relative magnitudes, it must be inferred that such a rock burst is an extremely high release of energy. This particular burst was, in fact, registered on the short-period Benioffs at Weston, something like 800 miles distant.

The enormous pressures obtaining at depth in this mine are shown by the end crushing of timbers, some of which are more than a foot square. (Fig. B) To provide some protection for men having to pass through danger zones, circular steel sets are built. These are 65 lb. rails, bent in arcs with the ball inward, and covered with closely set poles or lagging, the whole being covered by a foot or two of sand. In the case of a burst, such sets do not completely crush and tend to keep a way of escape open through drift sections of greatest danger. (Fig. C)

Attempts to time accurately the burst of December 27, 1938, at Kirkland Lake failed. At the invitation of Lake Shore Mines, the Dominion Observatory undertook to select and install suitable seismographic and timing equipment on the surface near the mine. The seismometer chosen was a seismic prospecting geophone made by Heiland Research Corporation, Denver, Colo. A special camera giving a paper speed of 30 mm/min. was also furnished by the same organization. A National Standard HRO radio set was purchased through the Canadian Marconi Company, Montreal. A special room was prepared by Lake Shore Mines containing a cement pier for the seismograph and developing equipment for handling the records. An anteroom provided space for the radio and timing equipment. The instruments began operating on December 19, 1939. (Figs. D, E, F, G.)

The seismometer is set in a small, cylindrical, cement-lined hole in bed-rock, about two and a half feet below the level of the basement floor in a house which provides living quarters for some of the staff of Lake Shore Mines. This small hole is central with a cement-lined rectangular hole in the floor. In this larger hole, a flat topped pier, shaped something like a knee-hole desk, is supported on two upright sections, strongly reinforced with steel rods which also tie it to the rock. The installation lies about 1,200 ft. SSW from the office building at Lake Shore Mines. (Fig. H)

During 1939, eleven bursts, great enough to register at Ottawa, occurred at this mine on the following dates: February 7, 19; March 11, 26, 28; April 30; August 31 (two bursts), September 2, 19 (two bursts). As these were prior to the seismograph installation at Kirkland Lake, no accurate velocity data could be deduced. Since December 19, many smaller bursts have registered (an average of more than one per day). A few of these were quite severe, but only one registered at Ottawa. This happened to coincide with a most extraordinary microseism storm which precluded accurate timing at Ottawa. There is, therefore, to date, nothing to report as to speed of propagation of the elastic waves.

After the seismograph installation was completed, Lake Shore Mines proposed further study in the mine itself. It was decided to prepare some tentatively arranged equipment and to experiment in the mine during March, 1940. Mr. Zack E. Gibbs lately of Harvard seismograph station and with wide field experience in similar problems, was recommended by the writer to assist in this work. A pen-recording equipment and an amplifier were built by Mr. V. Hollinsworth of the Dominion Observatory. A Heiland geophone was purchased as a pick-up for low frequency noises and a Brush DP-1 crystal pick-up was obtained for frequencies up to 5,000 cycles. The entire equipment was tested at Ottawa during the first week in March and then moved to Kirkland Lake. (Figs. I, J)

The recording apparatus and the amplifier were there built into a wooden box, provided with electrical connections and having a couple of lamps inside to keep out the mine dampness. The equipment was set up on the 2950-foot level on March 13 and continued to operate there until March 20. It was then moved to the 3950-foot level where it operated continuously until March 29. The mine noises were recorded better with the crystal detector than with the geophone. A sample record for March 19-20, using the crystal detector and operating on the 2950-foot level, is shown in the slide. (Figs. K, L, M)

The experimenting showed that blasting and small rock bursts registered in the same manner. There were no preliminary tremors giving warning of bursts. Blasting is done mostly from 2 to 3 a.m. and from 2 to 3 p.m. but small shots are set off at various points in the mine throughout the working shifts 7 a.m. to 3 p.m. and 7 p.m. to 3 a.m. daily. Rock drills, even when operating only about a hundred feet away did not record.

The experimental work also demonstrated that a greater paper speed would be required than that used -- about 8mm/min. There is some evidence from other sources that rock bursts set up frequency vibrations of 20 to 40 cycles per second, while blasts show 40 to 80 cycles. If this is so, filters can be used in the amplifier to cut out the blasting and record only mine noises as distinct from operational noises.

Unique conditions for rock burst study obtain at the west end of Lake Shore Mines. A "pillar" of ore extending from about the 3000 to 4000 feet in depth, the full width of the vein, and approximately 100 feet wide stands as a remnant. It is cut through by drifts at levels which are driven at intervals of 125 feet. This remnant is now being mined out, thus rapidly changing the stresses. A program of research proposed by the Dominion Observatory has been approved and adopted by Lake Shore Mines and will be directed to a study of this "100' pillar". (Figs. N, O, P) The position of the veins at this point is shown in a mine model, in a plan of the 3075-foot level, and in an elevation of the main vein.

It is proposed to develop experimental equipment in a new laboratory just being completed at the mine. The research will attempt to study:

(a) Mine noises and their chronological pattern.

(b) Variation from day to day in the velocity of elastic waves along selected paths in the pillar.

(c) Records of strain meters at strategic points throughout the mine.

(d) Variations of temperature indicated by delicate thermometric devices at points where the pressure is changing most rapidly.

(e) Displacements indicated by fault markers at all points when major faults cross the workings.

To study the noises it will be necessary to experimentally determine the position (or positions) in the frequency spectrum occupied by mine noises and develop equipment to record them continuously. For the velocity measurements, a camera must be built which will record for about one second and place accurate timing lines photographically at intervals of .001 sec. at paper intervals of about 5 mm. The thermometric equipment must also be developed experimentally and tested in special bore holes. Strain gauges and fault markers have been developed in various other investigations. An attempt will be made to secure the benefit of the experience of others in designing this equipment for use at Lake Shore Mines.

Dominion Observatory,
Ottawa, Canada.
May 15, 1940.