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Cosmic Ray Expedition to South Eastern Ladakh.

By J.M. Benade
Professor of Physics, Forman Christian College, ~~Punjab~~ University, Lahore.

In the summer of 1931 and Prof. A.H. Compton, of the University of Chicago, organized a world wide cosmic ray survey. The object of this work was to obtain measurements of intensities of this interesting radiation at various latitudes and longitudes as well as at various altitudes. These measurements were to be made by a dozen or more cooperating physicists in various parts of the world, during the summer of 1932. The necessary funds for the work were to be provided by the University of Chicago and the Carnegie Foundation. All observers were to use exactly ~~the same~~ similar apparatus, made and standardized in ~~the~~ Ryerson Physical Laboratory of the University of Chicago, so that all results would be strictly comparable. Heretofore each worker in this field has designed and built his own apparatus so that it has not been possible satisfactorily to compare results.

The writer was asked to make measurements in Ceylon, Java, Singapore, Penang, Rangoon, Calcutta, and Lahore and then at the highest attainable altitudes in the Himalaya. The first part of the work was completed early in July and by the 20th. of the month final preparations were completed for the mountain expedition. Our party consisted of Messers R.L. Wilson, Mela Ram, Bagh Shah Puri and the writer from Forman College, and Mr. R.K. Sharma of Ewing College, Allahabad.

Following the advice of Col. C.H. Stockley, and Major Kenneth Mason and others we had selected the ridge immediately to the west of ~~Thso Moriri~~ Moriri as our objective. Here we hoped to get to a high altitude without encountering serious difficulties due to snow. Our route took us via Pathankot and Kulu to the Rothang (Plain of the Dead) Pass where we stopped for a day to make our first measurements. Here we spent a cold night with a driving rain but the morning dawned clear giving us, for half an hour before the mists arose, a gorgeous view of many jagged peaks and several small glaciers of Lahoul and to the south a beautiful panorama of wooded hills and fruitful valleys. Two more days took us to Kyelang where we collected a few more supplies and information about our route. The Rev. and Mrs. Asboe of the Moravian Mission were most hospitable and helpful. I am glad to take this opportunity to express for my colleagues and myself our grateful appreciation of their unstinted assistance which was of great value to us.

On July 29th. we left behind us the last outpost of modern civilization with its post office and one Moravian home. Following the Kyelang-Leh road our next interesting stop was at Dozam, or as the survey maps have it, 'Patseo'. Here we found a fascinating collection of people from the north and south met to barter wool for grain as our forefathers did for ages before money was thought of. Primitive folk from beyond the passes are quite unperturbed by the threatened crash of the industrial system of the remote outside world. Reluctantly we left this very interesting group of shepherd-tradesmen, and, with many ^{unanswered} questions about their manner of life and future prospects, we moved toward the home of some of them. Two days later we stopped for our second set of readings on a knoll above the Paralatsa La (Baralacha) and then continued our way past Niepung Ludhpung, over the Lingti Plain to Sarchu, forded the Tsarap Chu and climbed over the tiring Lachalung La amidst scenery of surpassing grandeur. It is not surprising that this should be called "God's Pass." After a few miles more on the beaten path we reached Pang and turned eastward using the broad flat, and for the most part, dry, bed of the Sumkil Lungpa, as a roadway. No one in our party had ever been in this part of Ladakh before and as shepherds were not to be ^{when most needed} found we had to depend upon the survey map which gives few details. Following the map we crossed the Telekonka La (Little Peak Pass) about 16,500 ft. high and descended into the Phirtsu Pu. After a few miles we turned to the left and crossed a low spur into a wide valley and then crossed two ridges ^{beyond} to the foot of the Lanyar La (Sleeping Pass). In this region there are no clearly defined roads. One must follow sheep and yak paths or use his own judgment.

The approach to the Lanyar La from the southwest is long but not difficult. Our barometers indicated that the height of the pass must be about 19,000 ft. To the north of the pass is a small peak of coarse shale which proved to be very convenient for our purposes. On the top of this we pitched our observation tent and spent two full days ~~there~~ getting readings with two types of cosmic ray apparatus. Our height was approximately 19,500 ft. So far as we know this is the highest mountain work thus far done on cosmic rays. It happened that on the ~~very~~ 12th. of August while we were taking readings on this peak, Prof. Regener in Germany obtained his record high altitude measurements by sending a self recording electroscope up to about 17 1/2 miles with a pilot balloon.

One could doubtless follow the water course ^{east of the pass} to the lake but by turning to the southeast about two miles below the pass we moved directly toward Korzok. There were several easy ridges to cross and two fairly large streams to ford. It was not until we reached the top of ~~of~~ the pass at the head of the Korzok Pu (about 17,200 ft.) that we got our first view of the deep blue waters of Thso Moriri. At first only a small area of the lake was visible but as we descended, more and more of that beautiful gem and its magnificent setting spread out before us. Descending to a wide maidan we camped for two days on the green grass by the stream. While our ponies grazed and recovered in part from the previous strenuous weeks, we visited the village of Korzok, the Gumpa and the Lambardar, Thakur Nono Tshewan, who was very friendly and helpful. We were told that it is quite possible to climb nearly and perhaps quite to the top of the high peaks east of the lake, and that animals could be taken to well above 20,000, but no grass is available. A study ^{by means of a telescope} of both northern and southern slopes of these peaks indicates that it should be relatively easy to get to the very top. There would be comparatively little snow and ice work. However if animals are to be used ~~at~~ ~~all~~ grain must be taken for them and this is not available in Korzok so must be brought from Kyelang.

On the return journey two members of our party attempted to get to the top of the peak immediately to the south of the Lanyar La, with apparatus for observations there. After getting to within two or three hundred feet of the top we pitched a tent for the night. The boiling point was found to be 80.30 degrees centigrade, which corresponds to a pressure of 360 mm. of Mercury, or an altitude ~~of~~ in the neighbourhood of 20,000 ft. After a fairly comfortable night, we decided that the measurements we might make at the top ^{there} would hardly be worth the risk involved in the effort to get to ~~the top~~ so we regretfully turned back.

Our next set of readings were obtained on a round top just north of the Telekonka La and another set on the Lachalung La. Our last observations were made at Sarchu. The results are given in the following tables. In the first table the last column gives intensities of the radiation after passing through one inch of copper and two inches of lead in terms of the number of ionic pairs that would be produced per ~~per atmosphere~~ cubic centimeter of air, per second, per atmosphere of pressure.

	LATITUDE	LONGITUDE	ALTITUDE	ATMOSPHERIC PRESSURE	IONIC PAIRS
Rohtang	32° 22'	77° 15'	13150 ft.	477 <small>mm. Hg.</small>	5.15 4.60
Sarchu	32° 54'	77° 36'	14000 "	461 " "	5.00
Lachalung La (Demra)	33° 5'	77° 38'	16000 "	428 " "	4x60 5.40
Bara Lacha La.	32° 44'	77° 28'	16150 "	425 " "	6.12
Telekonka	33° 5'	77° 55'	16900 "	412 " "	7.27
Lanyar La	30° 0'	78° 5'	19500 "	377 " "	8.30

Barometric pressures were obtained by means of a Paulin instrument which probably reads two or three per cent too high.

October 2nd 1932.

In addition to the measurements made with the Compton apparatus we studied the effect of screens of various materials surrounding an ionization chamber while at the top of the small peak north of the Lanyar La, at an altitude of about 19,500 ft. ~~high altitude cosmic ray data using a similar apparatus mounted by a balloon, measurements were made at a mountain top in the Himalaya at an altitude of about 19,500 ft.~~ The results of these measurements indicate clearly that the ionization of gas in an ionization chamber is due at least in part if not entirely to a secondary radiation produced in the walls of the chamber and other surrounding media, by cosmic radiation.

The apparatus used consisted of a Lindemann electrometer with a thin walled aluminium ionization chamber and six screens of different materials. The screens were made ~~six sizes~~ as nearly as possible of equal size and weight so that the mass per unit area was the same for all. The screens should therefore, according to the usual assumption, have had equal absorption effects. Readings taken with and without screens surrounding the ionization chamber show that the presence of a thin screen of heavy metal actually increases the rate of ionization, while the effect of a paper screen is to decrease the rate of ionization.

The following table gives the results obtained for six screens used.

Various Shields Used.	Time for given Voltage Drop
With no Shield.....	100 seconds
Paper Shield	104.4 "
Aluminium Shield	100.6 "
Zinc Shield	92.3 "
Iron Shield	100.5 "
Iron Shield	92.1 "
Copper Shield	92.8 "
Lead Shield	82.0 "
Iron over Lead (Double) Shield	79.0 "
Lead over Iron (Double) Shield	82.3 "

It will be noticed that the heavier metals produce the greater positive effects. Presumably increasing the thickness of the the screens would increase the effects though of course in each case, *except paper,* within definite limits. The mass per unit area of the screens used is about 0.9 g/cm.

The above results may help to explain the discrepancies between the high altitude results obtained by Kolhorster, Regener, and Piccard, for it is obvious that the density and thickness of the ionization chamber walls must have a considerable effect on the shape of the curves obtained ^{with} different instruments. This is probably especially true at very great altitudes.

As a result of our experience it seems clear that it is quite possible to get to an altitude of 20,000 feet or more with loaded pack animals, provided of course adequate preparations have been made before starting. It should be quite possible to spend several days at such an altitude in comparative comfort while making observations.

The data obtained by means of the Compton apparatus have of course been forwarded to Doctor Compton to be studied along with ~~other~~ data from other parts of the world. Work is being continued with ~~the~~ our own apparatus in the physics laboratory of Forman College, Lahore.

In conclusion I wish to express my gratitude to Prof. Compton for the privilege of sharing in this cosmic ray survey and to my friends and colleagues in the expedition without whose help this work would have been impossible. I desire ~~to~~ to thank Messers Bell Ram Brothers, Anarkali, Lahore, for the medical equipment with which they provided us, and The Bhalla Shoe Company, Lahore, for supplying us with boots which served us excellently, and also The Lahore Industries Ltd. for supplying us with tinned peas and gram as well as very good ketchup and chutney. And finally I must mention our interpreter Gápal, and ponymen Anno, Zigzin, Namgyal, Dhangrup, Kunga Dhangrup, Urgian, and especially Nawáng, a young lama of fine physique, intelligence, and good nature.

J. M. Benade,
Professor of Physics,
Forman Christian College, Lahore.
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