

LETTERS TO THE EDITOR

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THE FLUORSPAR DEPOSITS OF RAJ NANDGAON AND KHAIRAGARH STATES, EASTERN STATES AGENCY, CENTRAL PROVINCES

IN this communication, attention is confined to the fluorspar deposits of the States of Raj Nandgaon and Khairagarh. These deposits were examined by Dr. Chhibber, while the collection was studied conjointly by him and Mr. I. C. Pandey.

There are two ways of approaching these deposits. One of them is via Raj Nandgaon and then a journey of 26 miles takes one to the deposits. They are also accessible from Dongargarh which is a railway station, about fifteen miles by road from these deposits.

Previous Literature.—There are passing references to this deposit by Thomas Oldham¹ and W. T. Blanford.² There is also a paragraph in the Director's Annual Report for 1938-39. Reference to this deposit is also made by Dr. M. S. Krishnan,³ wherein it is stated that Dr. J. A. Dunn visited the deposit.

Physical Features.—These fluorspar deposits form two small hills running practically in a north-south direction and are separated by the Great Eastern Road. These hills rise from the surrounding flat granite country and the locality is locally called Chandi Dongri because of the association of the argentiferous galena with these deposits. The northern hill lies in the State of Khairagarh while the southern hill is situated in Raj Nandgaon State. The Khairagarh hill is about 70 feet above the level of the Road.

Geology.—The geology of the country is represented by the following rock-types:—

- (iii) Silicified Granite.
- (ii) Fluorspar Pegmatite.
- (i) Granite.

The country-rock is a porphyritic granite, clearly exposed in the streams. Outcrops of this rock are seen in places; otherwise it is

covered with soil or subsoil, sometimes with a heavy over-burden. The following profile section was observed, in descending order, in a quarried face of the granite in the northern hill in the Khairagarh State:—

- (1) Blackish soil mixed with gravel and humus in which pieces of fluorspar are occasionally found. It is about two feet in thickness.
- (2) Reddish soil in which quartz grains are very conspicuous. It is locally known as *moorum*. It is lateritic in character and the felspar has changed into clayey material. It is about four feet in thickness.
- (3) Below (2) decomposed granite is exposed in which felspathic veins are seen running in all directions.

Deposit of Fluorspar.—The locality, where fluorspar is known to occur, is locally known as *Chandi Dongri* (meaning silver hill) because of the association of argentiferous galena with the deposit. However, the argentiferous galena occurs only in very small quantity; it being almost absent in the southern Nandgaon hill.

The mineral fluorspar occurs in a pegmatite, which is intrusive into the granite and which runs in a dyke-like fashion practically in a north-south direction. It has a maximum width of about 64 feet and in places inclusions of the granite are enclosed in the pegmatite.

Khairagarh State.—The northern hill, as already noted, lies in the jurisdiction of the Khairagarh State and was being worked at the time of the first author's visit in November 1941. The overburden had been removed and fluorspar was being extracted from the central portion of the pegmatite. It has an average fluorspar content of about 22 per cent., a little more than that of the Nandgaon hill, and the workable length is only about 400 feet from the road. The width is about the same as in the Nandgaon hill.

Nandgaon State.—The southern hill, across the road lies in the Nandgaon State. The dyke, in which fluorspar occurs, is about 30 feet in width on the average which in places dwindles down to 12-15 feet. The pegmatite appears to have almost vertical walls on either side. Towards the northern end, the dyke is more quartz-bearing, but it is also rich in fluorspar. Towards the southern end it assumes more felspathic character which has little fluorspar.

Mode of Occurrence of Fluorspar.—Fluorspar occurs in veins, the maximum thickness observed being about five inches. In some cases lenses of the country-rock also occur in these veins. Fine stringers are also commonly observed. In one place these veins were observed in coarse granite with pink felspar. Fluorspar and quartz are the main minerals forming these veins. It may be noted that blocks of what appeared like breccia were also observed. This breccia is apparently fault breccia and it is along this fault that the fluorite-bearing pegmatite intruded itself. Some of the blocks have a cavernous appearance filled subsequently with fluorspar, quartz and occasionally argentiferous galena. Sometimes fluorspar is deposited evidently in crevices in the rock.

The rock is highly crushed and is traversed by joint cracks running in several directions. Some of these cracks are hardly one-eighth of an inch apart and in these cracks fluorspar is deposited. Minute specks of green malachite are also observed.

Fluorspar, mostly mauve in colour, also occurs in irregular lenticles or patches. Those measuring four inches by two inches are not uncommon, but occasionally those having dimensions of two feet by three inches are also observed. Towards the crest of the hill the rock is richer in fluorspar than on the flanks. This mineral is also found associated with siliceous cavernous gangue, e.g., near about 300 feet, from the main road, in the Khairagarh hill.

Physical Characters of Fluorspar.—The form is usually massive and compact. The colour is variable. It is whitish, greenish, bluish, violet-blue, pinkish and dark purple in colour almost approaching black. The streak is white. The lustre is vitreous. One set of cleavage is perfect. The fracture is splintery, subconchoidal. Hardness is 4. The specific gravity, as determined by Jolly's balance, is 3.0.

Microscopic Characters of Fluorspar.—The fluorspar occurs in granular form and also as metacrysts which show subhedral forms. One set of cleavage is perfect while the other is imperfect. It is observed to be intergrown with quartz and felspar which is clouded. In thin sections it is colourless but sometimes pinkish, purplish or bluish shades are to be observed. The mineral is isotropic. Some galena occurs in association. A little axinite and a few specks of chalcopyrite also occur.

Chemical Composition.—The following two chemical analyses of almost average specimens of the fluorspar rock were done by Mr. I. C. Pandey.

	I	II
SiO ₂	19.56	10.12
R ₂ O ₃	8.32	9.12
CaCO ₃	3.105	5.10
CaF ₂	68.52	72.15
H ₂ O +	0.32	1.32
H ₂ O -		
	99.825	97.81*

* PbO is present in small quantity.

I and II.—These almost average specimens are from the Khairagarh hill, where fluorspar was being extracted in November 1941.

The analyses show that the percentage of silica, which is in the form of quartz, varies from 10.12 to 19.56 while CaF₂ is in the neighbourhood of about 70 per cent. CaCO₃ varies from 3.105 to 5.10 per cent.

Working of the Deposit.—It appears that Messrs. Tata Iron and Steel Co. have carried on considerable prospecting in these hills. Towards the end of 1941, they had applied both to Nandgaon and Khairagarh States for mining leases, which were likely to be granted shortly. The Tatas were quarrying the rock with manual labour and they hoped to raise about 3,000 tons of fluorspar *per annum* with about 100 workmen. This fluorspar will be utilized in the manufacture of steel. In November 1941, experiments on hand-sampling, hand-dressing, etc., were being carried on. After quarrying, the rock is hammered into small pieces and those of fluorspar are separated by hand-picking from the gangue. Several stacks of fluorspar were found lying near the hill.

Origin of Fluorspar and History of Igneous Activity.—The history of igneous activity of this deposit may be briefly described as follows:—

(1) First, there was the intrusion of the main mass of the granite.

(2) In the granite there was the intrusion of the felspathic pegmatitic dyke. It has almost vertical walls and stands out very clearly from the surrounding decomposed granite.

(3) The pegmatitic phase was followed by the pneumatolytic phase when the vapours of fluorine, silica, etc., were responsible for the deposition of secondary clear quartz, fluorite, etc. It was usually observed that clear quartz and fluorspar generally occur together, showing that vapours of fluorine and SiO₂ acted together. When the dyke is entirely felspathic, it is almost surely devoid of fluorspar. In the siliceous or quartz-bearing rock, fluorspar is more likely to occur.

(4) Finally came the hydrothermal phase which was responsible for the dissolution of the felspathic material and the deposition of whitish chalcedonic or yellowish jaspery silica instead. It was observed that fluorite in this material was conspicuous by its absence. It appears that this form of silica was definitely deposited by the hydrothermal phase and by that time the vapours of fluorine, etc., belonging to the pneumatolytic phase, had ceased activity. Honey-combed cavernous structure is observed in places where quartz of the granite is still intact but by the dissolution of

the felspar, the cavernous structure has developed. These etched out spaces were subsequently filled with the white or yellowish silica.

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November 16, 1944.

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1. *Revs. G.S.I.*, 1868, 1, 37.
2. —, 1870, 3, 44.
3. —, 1939, 74, 406.

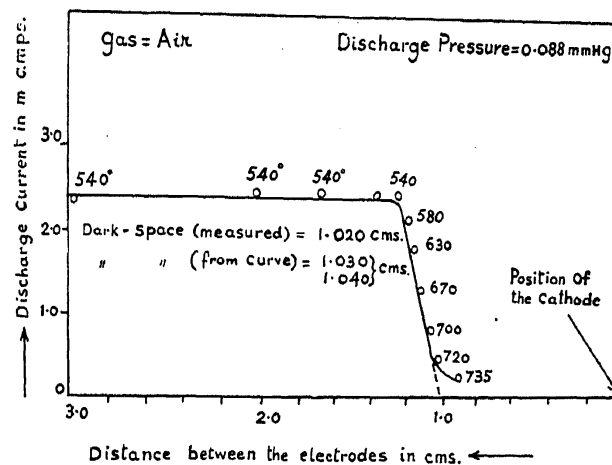
ON THE CATHODE DARK-SPACE OF A GLOW DISCHARGE IN GASES AT LOW PRESSURES

A NUMBER of experimenters^{1,2,3} have studied the characteristics of the cathode Dark-Space and they all agree that this is the most active region of a glow discharge. The views held by different investigators on the mechanism of the flow of current across the Dark-Space are, however, very divergent. Thomson⁴ believes that the ionisation in the space is caused by electrons which themselves are emitted from the cathode surface by the impact of the positive ions so produced. This theory finds a good support from the experiments of Oliphant⁵ on the secondary electron emission from metals by positive ions. The entire supply of the ions to the cathode is, according to them, from the Dark-Space itself and very few of them flow into it from the negative glow and particularly so when the discharge is normal. Moreover, they consider it probable that on account of their high density in the Dark-Space some of the ions flow back into the negative glow. Loeb⁶ takes the reverse process to be more probable. Ryde⁷ and Compton and Morse⁸ also hold that it is the negative glow which acts as a source of the positive ions. They further assume that this section of the discharge behaves like an emitter of the ions and the cathode as a collector of them, the relation connecting the cathode fall, the Dark-Space length and the discharge current being of the same form as the Langmuir's Space-Charge Law which is true for electronic emission from a hot metal in a high vacuum. There is, however, no direct experimental evidence in favour of any of the above assumptions.

We have carried out experiments with two plane parallel electrodes in a discharge tube, the anode being moveable. It is observed that as the anode is brought closer to the cathode there is no variation in the discharge current or the voltage till the former reaches a point in the negative glow a few mm. away from the boundary of the cathode Dark-Space. If the anode is pushed further towards the cathode the current regularly falls but the voltage required to maintain the current rises continuously. The fall in the current is linear with the displacement of the anode till it reaches a point near the edge of the Dark-Space. Beyond that the current diminishes much more gradually.

A large number of curves connecting the discharge current and the distance between the electrodes have been obtained. The curve

in the figure typifies the results in Air and Oxygen. The voltage required to maintain the



discharge current at varying distances between the electrodes is given along the curve at each step. If the straight falling part of the curve is produced to cut the distance axis the point of intersection of the two lies away from the cathode equal to the width of the cathode Dark-Space which was measured usually with the help of a cathetometer. This applies practically to all the curves.

The experiments have been carried out in air over a pressure range, 0.043-0.142 mm. Hg, voltage range, 350-950 volts and current range, 1.2-4.0 m.amps.; corresponding values for oxygen are 0.112-0.165 mm. Hg, 400-520 volts and 1.8-3.2 m.amps.

We have come to the following conclusion from these experiments:—

1. The positive ions reaching the cathode do not all come from the Dark-Space but a considerable number of them flows into the Dark-Space from the negative glow under all conditions of the discharge studied.
2. The discharge current is carried across the common boundary of the Dark-Space and the negative glow both by the cathode rays and the positive ions travelling in opposite directions.
3. The length of the negative glow which acts as a source of the positive ions to the Dark-Space depends upon the discharge voltage and pressure.

Details of the experiments will be published elsewhere.

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January 2, 1945.

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