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MINERAL SURVEY REPORTS
JAMMU & KASHMIR GOVERNMENT.

PRECIOUS AND SEMI-PRECIOUS
GEMSTONES

OF

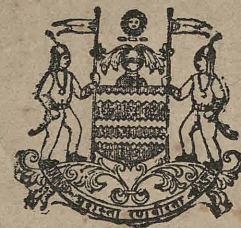
JAMMU AND KASHMIR

BY

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*Superintendent, Mineral Survey, His Highness' Government,
Jammu and Kashmir.*

(with Plates 1 to 7).



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MINERALS JAMMU AND KASHMIR
PRECIOUS STONES SURVEYS



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PRECIOUS STONES

PREFACE

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This account of the Precious and Semi-precious Gem-stones is the ninth, and last, of the present series of reports printed by order of His Highness' Government. Nominally it completes the record of the economic minerals of Jammu and Kashmir, so far as they are at present known.

Absolute finality, in compilatory work of this sort, is of course impossible; for the simple reason that, during the period occupied in writing, setting up the type, preparing and printing the maps and other illustrations, and issuing the finished reports, fresh information keeps coming in and accumulates. This new material, relating either to old areas reported on or to other entirely new areas and minerals, is already far from negligible, and points to further compilations being necessary at some future date.

For the time being, however, a pause is indicated. The compilations on which I have been engaged have indeed been most interesting and absorbing, and have taken longer than I expected; but they are now at last finished. With their completion, I take the opportunity of tendering my grateful thanks to His Highness the Maharaja Bahadur, for having extended my period of service so as to enable me to accomplish this.

W T

As regards the source of the material for the present account, it will be seen that Mr. Joti Prashad, B. A., F. G. S., Assistant Superintendent, Mineral Survey (retired), was the first active pioneer in discovering and investigating many of these precious and semi-precious gem-stones, at a time when he, as Mining and Prospecting Officer, was carrying on, single-handed, duties similar to those since taken over by the reorganised Mineral Survey under my direction. Hence, nearly all the earlier references to these gem-stones, herein given, depend for their data on that pioneer work carried out, often under difficulties, by Joti Prashad. Most of the detailed field-work, and practically all the more important discoveries made in the Padar district, are, however, of more recent date and must be credited to Assistant Superintendent Labhu Ram Badyal, M. Sc., whose energy and resourcefulness in the field I cannot too warmly commend.

The arranging and working of the gem-cutting experiment, described at page 24 of the report, was carried out by Joti Prashad with the co-operation of Pandit Hira Nand Raina, B. Sc., LL. B.

Handwritten notes and signatures at the bottom right of the page.

Much detailed descriptive work, in connection with engineering and other proposals for the working of the Sapphire Mines, has been contributed by Mr. L. Zutshi, B. sc., A. R. S. M., F. G. S., late Mining Engineer to the Government.

No chemical work has been required during these investigations, and no outside authorities have so far been officially consulted on any questions concerning the gem-stones; but Mr. Albert Ramsay of New York, a specialist in precious stones, visited the State to inspect the sapphire collection in the Toshakhana; and, at His Highness' request, selected and sent out to us an up-to-date lapidary outfit. This only arrived recently and has not yet been able to be made use of for any further gem-cutting experiments.

Subjoined is a full list of published reports on Kashmir minerals that have so far appeared since the Mineral Survey started work in 1917, including the present report. The first three of these appeared in the *Records of the Geological Survey of India*. The last nine were published by order of His Highness' Government and printed some at the Ranbir State Press, Jammu, others by Thacker & Co., Calcutta and the one on Ore Deposits by the Times of India Press, Bombay :—

- (1) Note on the Aquamarine mines of Daso on the Braldu R., Shigar Valley, Baltistan (published in *Records Geological Survey of India*, Vol. XLIX, pt. 3, 1918, with plates 6 to 10).
- (2) Possible occurrence of Petroleum in Jammu Province: Preliminary note on the Nar-Budhan dome of Kotli Tehsil in the Punch Valley, (published in *Records Geological Survey of India*, Vol. XLIX, pt. 4, 1919 with plates 13 to 16).
- (3) Lignitic Coalfields in the Karewa formation of the Kashmir Valley, (published in *Records Geological Survey of India*, Vol. LV, pt. 3, 1923, with plates 28 to 30).
- (4) Abrasives : Note on the Polishing material of Risin Spur Khunamuh near Srinagar, (printed by order of the Kashmir Government, with plates 1 and 2).
- (5) The Graphite deposit of Braripura, Uri Tehsil, Kashmir, (printed by order of the Kashmir Government, with plates 1 to 5).

- (6) Ochre deposits of Nur Khwah, Rata Sar and Jhuggi in the Jhelum Valley, Uri Tehsil, Kashmir, (printed by order of the Kashmir Government, with plates 1 to 6).
- (7) The Gypsum deposit of the Lachhipura, Bagna, Islamabad, Limbar and Katha nalas, Uri Tehsil, Kashmir, (printed by order of the Kashmir Government).
- (8) Bauxite deposits of Jammu Province (printed by order of the Kashmir Government, with plates 1 to 17).
- (9) A Resurvey of Jammu Coalfields : The Kalakot, Metka and Mahogala fields (with notes on the Chakar, Chinkah and newly discovered Dhansal-Sawalkot fields), (printed by order of the Kashmir Government with plates 1 to 25).
- (10) Ore deposits of Lead, Copper, Zinc, Iron and other metals, in Jammu and Kashmir State, (published by order of the Kashmir Government, with plates 1 to 16).
- (11) The Non-metallic Minerals of Jammu and Kashmir (printed by order of the Kashmir Government, with plates 1 to 7).
- (12) Precious and Semi-precious Gem-stones of Jammu and Kashmir (printed by order of the Kashmir Government, with plates 1 to 7).

(Sd.) C. S. MIDDLEMISS.

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PRECIOUS and SEMI-PRECIOUS
GEMSTONES of JAMMU and KASHMIR,
by C. S. MIDDLEMISS, C.I.E., F.R.S., F.G.S.,
Superintendent, Mineral Survey, His Highness'
Government, Jammu and Kashmir.

INTRODUCTION.



A halo of romance inevitably surrounds the subject of precious stones, because of their beauty, durability and rarity. This is enhanced, in the case of those of Jammu and Kashmir State, by the fact that, to the above three cardinal attributes must be added those of virtual inaccessibility and danger. The outcrops lie hidden away in the heart of the higher and remoter parts of the mountains, so that the accredited searcher after these gems must not only contend with nature in some of her wildest moods. but, alas for human depravity, with adventurous gangs of hardy smugglers, who have recently sprung up and come to regard these regions as their own particular hunting grounds, even though their illicit trade is fraught with considerable peril to themselves, now that the mine area is adequately policed.

Romantic aspects.

Although found now chiefly in these far distant and lofty positions, it is certain that most of these gemstones have originated at great depths in the heated interior of the earth, that they were in fact of hypogene origin, developed by hydro-thermal processes from magmas or rock melts.

Hypogene origin.

Hence their associations now are with granitic or other igneous intrusive masses, piercing the older rock intrusions. and more metamorphosed crystalline schists; or, as is still more frequently the case, richly concentrated in the pegmatite offshoots from those igneous rock masses.

Associated with igneous rock intrusions.

The most important gemstone that characterises these outlying parts of His Highness' dominions is corundum (chemically, pure alumina, or oxide of aluminium, Al_2O_3) under the form of sapphire.

By the possession of this mineral substance, Kashmir may be regarded as forming a part of the greater Indian Empire, which, as has been pointed out by Sir Thomas Holland in his memoir on corundum¹, can with very good reason be claimed as the home of corundum—the name itself being only a modification of the Sanscrit word *Korund*. For, as the above author writes :—

“Not only are there large deposits in India of the common form of this mineral, but the most highly prized specimens of its transparent red variety—the ruby—have been obtained from the famous mines of Burma, whilst the mines of Kashmir are noted for the size and transparency of the blue variety of sapphire”.

Many people doubtless can remember the dramatic appearance on the scene of Kashmir sapphires, which took place only as far back as the year 1881, and the rise to fame that crystals of them experienced by being described and figured in the world's literature of minerals and precious stones. This was unfortunately succeeded by an equally tragic failure in the outturn of the gemstone a few years later.

It seems that the pockets of sapphire at the spot now known as the “Old Mine” and the placer deposit at the foot of the scarp began to fall off in their yield, and at last became apparently exhausted, in spite of a Geological Survey officer sent to investigate the matter and of the activities of the Kashmir Mineral Company which had leased the working of them at a still later date.

Kashmir's short-lived sapphire boom had apparently petered out.

¹Manual, Geology of India, Economic Geology, pt. 1, Corundum.

However, the present writer, by means of systematic search done at the mines and neighbourhood by the younger members of the Mineral Survey, has since had the privilege of showing that this supposed failure of sapphire is by no means a fact, even in the vicinity of the original mines, and, in addition, of making known several discoveries of fresh stores of sapphire and some small finds of ruby at several entirely new localities. These will be fully described in the sequel.

Whatever success may eventually reward the many other discoveries of economic minerals and ore deposits made by that survey during the last 12 years, and which have been dealt with in detail in the preceding published reports of this series (always assuming that the deposits are properly developed and made accessible), it will be shown presently that the success which awaits the revival and reopening of the sapphire-bearing veins of Padar is expected to be an immediately realizable one, and that in all probability it will prove to be lasting.

In addition to the sapphire and ruby forms of corundum, which alone merit classifying as precious, there remain to be discussed the following gemstones of semi-precious quality, namely :—beryl (aquamarine), rubellite and green tourmaline, quartz (rock crystal), feldspar and serpentine.

Of these the most promising is the aquamarine of Daso. A report on this was published in the *Records of the Geological Survey of India* (see list at end of Preface). For the rest, the information at the author's disposal is not great. These semi-precious stones have only received passing attention during the course of other investigations. Such notes as can be made on them will be found in the following pages. All except serpentine occur similarly to corundum, that is to say, chiefly in pegmatites; and it is quite possible that their exploitation as a side-line along with that of sapphire would give some good results, and lead to the production of a pleasing set of variously coloured moderately valuable gems.

SAPPHIRE.

I. ORIGINAL LOCALITY OF SOOMJAM (SUMSAM),
PADAR DISTRICT.*Discovery and early History.*

The locality of the famous sapphire mines of Soomjam (Sumsam of the new maps), Padar district, is now known to be in lat. $33^{\circ}-27'$ long. $76^{\circ}-23'$. The mines lie $2\frac{1}{2}$ miles W. 30° N. of Soomjam (the highest village—consisting of a few houses—on the south side of the lofty hill range dividing Zanskar from the Chenab drainage area) and $2\frac{1}{2}$ miles due north of Dangel, which latter place is situated in the valley of the Bhut Na (river), just at the junctions of the Bhujwas and Dharlong nalas. Not very far away lies the southern border of His Highness' dominions, fronting Chamba, Pangti, Lahoul and Kulu, a circumstance that for long has been the cause of innumerable border raids carried out either for the sake of the *Kuth* root (a valuable vegetable product) or for sapphire.

The rock mines lie at elevations between 14,800 and 14,950 feet and the placer deposit at the base of the ridge at about 14,250 feet. At these high levels the surface of the ground, when free from snow, presents to the eye rocky ridges, clearly stratified, from which descend steep fans of scree material often grass covered down to an undulating upland valley, triangular in shape, and filled with old moraine and detrital material and sometimes with snow-beds that continue unmelted long into the summer.

The mines were discovered about the year 1881-1882 by accident. Several stories have grown round the event which were subsequently summarised in T. D. La Touche's paper in the *Records of the Geological Survey of India*, Vol. XXIII, pt. 2, 1890. Omitting these doubtful claims here, it seems certain that the

Locality.

Elevation.

Discovery.

gemstone was eventually brought into Simla by traders and recognised. In 1882 it was examined and identified by Mr. F. R. Mallet of the Geological Survey of India, who published a full account of its mineralogical and chemical characters in *Records of the Geological Survey of India*, Vol. XV, p. 138 and later in the *Manual*, pt. IV, p. 40 with figures of the crystals.

The first official of Kashmir State who visited the place was Wazir Zoarawar. He collected some quantity of sapphire. Other State officials were also sent on this mission, who in their turn, also made a further collection. General Baz Singh was one of those and he worked the deposit for several years and won large quantities of sapphire. The last State official sent was the late Major Balak Ram, who, it is reported, did a good deal of washing and blasting at the mine area, which then began to shew signs of exhaustion.

The Kashmir Durbar in 1887, on finding a steady diminution of revenue from the mines (which had been worked by them with considerable profit, since the first discovery) applied to the Government of India for a geologist to examine them, and secured the services of Mr. T. D. La Touche, then of the Geological Survey of India, who visited the locality in the early part of September of that year. His account of the results obtained was published in the volume of the *Records of the Geological Survey of India* referred to above, and was the first scientific description of the area, its surface features, geology, petrology and the mode of occurrence of the sapphire.

La Touche was unable to do anything to improve the prospects of the rock mines, except that he found on the north side of the ridge large blocks of corundiferous granite which he could not trace to their source. Some of the corundum was of a bluish tint. But, by carrying on washing operations on the placer deposit with the aid of a roughly constructed platform and sluice made of planks, he obtained a moderate amount of small gemstone which he did not

Mr. La Touche's visit in 1887-1888.

think very encouraging. The largest stone of good colour collected in this way in 1887 weighed about 16 tolas the largest in the following year about $\frac{1}{2}$ tola.

The photographs and a plan of the mine area on a scale of 1 inch to 600 feet, reproduced with his published paper, are of much interest.

Afterwards the area was leased out to the Kashmir Mineral Co., on whose behalf Mr. C. M. P. Wright did much washing of the placer deposit in the valley below the mines, by means of water led by a canal across the ridge. When the last of the earlier efforts of licensees to work these mines was made by Mr. Wright in 1908, the takings were considered unsatisfactory; and, ostensibly on that account, this classical source of the famous Kashmir sapphire has been practically neglected ever since until quite recently.

The vein from which extraordinarily large lumps and crystals of this gemstone were originally got, was situated at the place marked "Old Sapphire Mine" on the plan (Pl. 3). It had, however, long ago ceased producing: and the partly-rounded pieces and pebbles of it, that had fallen down the slope and become enclosed (along with other broken rock) in the placer deposit in the valley, had also become scarce or at least difficult to obtain.

In these circumstances it was generally supposed that Mr. Wright's last venture in sapphire getting during the summers of 1907 and 1908 was not adequately remunerative, even though he had then discovered a new vein of rock-sapphire at the place now known as the "New Mines".

The present writer happened to see Mr. Wright's takings, made during one or other of his last trips to the mines. He brought them one day to the Geological Survey of India office and declared himself dis-

satisfied with the result. The writer was not so much impressed with the poorness of the takings (which seemed to him very fine) as with the local difficulties and hardships he had had to contend with in those remote and elevated regions.

Whatever the precise deterring causes, Mr. Wright did not repeat his visit to the mines. Lala Joti Parshad visited them as Mining and Prospecting Officer in 1911. It is well known that his results from the south-west opening of the New Mines were rather poor, consisting only of large quantities of grey and semi-translucent corundum, without any blue pieces as far as known, and which were sold altogether for the relatively small sum of Rs. 1,000.

Since then, in 1920, the mines were leased out to Messrs. Sohnu Shah of Jammu, without any apparent results of importance emerging; no details as to proceeds and sales of the royalty portion being available in this Department. Gradually it came to be believed that the sapphire mines were exhausted.

Then came the survey of Pandit Labhu Ram (at that time Junior Assistant Superintendent Mineral Survey) in 1924, when he mapped the area of the Old and New Mines on a scale of 1 inch to 200 feet. This was the beginning of a new order of things. He brought back accurate data and indicated in his report and on his map several spots where corundum and sapphire were still to be found *in situ*. He also brought back small samples, which were all he could collect during the 12 days to which his stay at the mines was limited owing to bad weather and other unforeseen hindrances.

His efforts, however, bore fruit two years later in 1926, when Lala Jagan Nath of Jammu took out a prospecting license and obtained a large quantity (about 5,500 tolas¹ weight)

¹One tola=1 rupee weight=180 grains Troy.

of rather small crystals of corundum, having blue patches and portions of crystals here and there, from places at A—A on the large-scale plan of the New Mines (see pl. 4) which Pandit Labhu Ram had pointed out as promising.

Owing to certain irregularities committed by him and to the open workings which he left unprotected so that thieves afterwards raided them, Lala Jagan Nath's license was not renewed. (He had been allowed to work the mine, without any *motamid* or other Government officer accompanying him, because of the still prevalent idea that the mines were exhausted and that, until he struck something good, such precautions would be superfluous. It was also seen by the Kashmir Government that the State Mining Rules were in urgent need of revision).

Instead, the Kashmir Government decided that the Mineral Survey should conduct an experimental working of the area during the following summer of 1927, in order to find out what was the real state of the mines. After many delays Lala Joti Prashad, was deputed to do the actual mining work and Pandit Labhu Ram was to assist him and also to go on with the petrological exploration work in the region begun by him in 1924. The latter officer started several weeks ahead of Lala Joti Prashad, with the additional object of doing what he could to safeguard the mines from the continued raiding, which was being actively carried on both from within and outside the border, until the newly assembling police force settled down to work, and until the arrival of Lala Joti Prashad. The results of their joint efforts are given below.

Exploration of the Mine area and neighbourhood in 1927.

This exploration work was carried out by Pandit Labhu Ram and the results here given are based on the detailed report which that officer submitted.

Experimental working by the Mineral Survey in 1927.

Labhu Ram's report.

In this summary and review no attempt will be made to treat the subject in the logical order which Pandit Labhu Ram has adopted in his report; but the object will be to explain the situation from a different standpoint—proceeding from the concrete to the general: from what is familiar to what is more obscure.

The most obviously tangible fact appertaining to these last **Corundum-sapphire from New Mines.** two years operations is that whilst the Old Mine and placer deposit have yielded either nothing more or have been neglected for the present, large quantities of corundum-sapphire have been dug up in excavations at a central point of the New Mines area. This material, including that got by Lala Jagan Nath, was brought down to Jammu, and many Members of Government have since seen and handled it. It will form a convenient starting point for descriptive purposes; and it is consequently necessary first of all to get some definite idea concerning its outward appearance, shape, size and qualities.

At a first glance, the heaps of material, as taken from the sealed boxes and bags, suggest piles of kankar. The so-called crystals appear as rather shapeless elongated pieces, slightly less than a finger in length, a little broader than that in the middle and tapering away at each end spindle-fashion. All are almost entirely coated with a white incrustation, a thin pellicle of strongly adhering kaolin, that gives them the appearance of having been dipped in whitewash and allowed to dry. All regularity of crystal surface is disguised thereby and also by the further fact that a large proportion of them seems to be pitted or corroded into holes and unevennesses.

On closer examination, beneath this surface coating, the underlying corundum-sapphire material shows up here and there in milky-grey, bluish grey or blue-black colours. At these spots also traces of plane surfaces can be made out which can be pieced together as portions of the crystal faces of an elongated double hexagonal pyramid. Generally some imagination has to be used

Outward appearance of takings.

Crystal habit, etc.

to effect this, but occasionally we come upon a larger part of the crystal (generally at the apex of one of the pyramids) which is entirely free from the kaolin coating. The crystal outline and the regular faces meeting together at their common edges then become plainly visible, each face being finely ruled with parallel horizontal striations at right angles to the long axis of the crystal. The edges of the pyramids do not quite meet at a point, the summit being generally truncated by a small but definite crystal face (the basal plane). Similarly the crystal faces of the upper pyramid do not join sharply in a downward direction with the similar faces of the inverted pyramid below. There appears to be a zone of indecision, of alternations of the two sets of planes; but there are no regular prism faces, that is to say, hexagonal prism faces like those so prevalent in beryl and aquamarine and in some corundum from other places and countries. Practically all the crystals, whether dull, translucent or transparent and blue-tinted, are free from any prominent pseudo-cleavage or parting planes, which on the other hand are usually very noticeable in common opaque brown or grey corundum such as that from Salem district S. India, the horizontal striations referred to before being due to quite other causes, and not affecting the interior of the crystal. Hence there is no special tendency of the substance to split up along divisional planes, its fracture being uneven and sometimes conchoidal, a valuable property for all commercial purposes.

Coloured portions. These large patches or solid portions of the crystal where the kaolin coating has scaled off look blue-black by reflected light, but when held up against the light are seen to possess in different degrees the proper sapphire tint from pale to azure and deep blue.

The difference between the common grey or pale translucent blue-grey corundum crystals and those with a considerable sapphire portion is extreme, and is illustrated in Pl. 5.

Common grey variety. The common variety, fig. 1, is rough and irregular, the coating of kaolin being irregular and merging into or penetrating into the grey and blue-grey translucent central part.

Blue variety. Those with a valuable sapphire portion, fig. 2, exhibit the latter unmistakably. The coating of kaolin is thin over such parts and readily scales off with a little scrubbing and scraping. Among a hundred of the common greys and blue-greys there may be only a few with clean sharp sapphire portions.

Mode of occurrence at the mines. We have now to trace the corundum-sapphire material backwards to its home in the New Mines area, and to consider the matrix in which it lies embedded and the geological conditions under which it occurs. Our evidence here is different from that based on the takings lying in Jammu treasury. It is a matter of data collected by Pt. Labhu Ram; and we must journey in imagination to the mine area and accept the latter's conclusions, fortified as they are by detailed maps and an illustrative series of collected specimens.

Kaolin matrix. When we finally stand in imagination in the triangular valley at 13,500 feet near the rock-shelter called "Kudi" and look north and north-east, the locality of the New Mines can just be seen high up on the bare and precipitous slopes before us (see Pl. 2). If we attain this point at 14,775 elevation after an arduous climb we shall find that the actual spot is only an insignificantly small pit a few feet wide and deep, and that the matrix of the corundum-sapphire is an equally small patch of white kaolin or china-clay, tough rather than hard, and that has to be extracted from the pit in lumps or fids, just as one would dig any compact tough clay; and we should further find that the patch of kaolin matrix is limited in area and shape to an irregularly lenticular, disc or cake-like body, over a foot in thickness extending for about 17 feet along its N.—S. axis, and 10 or 11 feet in depth, as far as at present worked. This lenticular or flat cake is nearly vertical, with a slight underlie towards the west.

Pegmatite with sapphire, tourmaline and garnet. The lower we sink into this lenticle the more tough and hard the kaolin becomes, until in some places it is hard rock, the kaolin having given place first to mixed felspar and kaolin and last of all to a

rock that is chiefly solid felspar as a matrix with the corundum-sapphire firmly embedded in it, along with a little tourmaline and other rarer constituents of the "pegmatite" (which the lenticle has now become)—pegmatite being a coarsely crystalline variety of vein-granite, not only rich in felspar and mica, but frequently containing also tourmaline, small garnets and one or other of the rarer accessory minerals peculiar to pegmatites, such as beryl, aquamarine and more rarely corundum. It is the occasional presence of these in pegmatites that makes the latter valuable as repositories of precious and semi-precious gemstones.

Proceeding to explore further in imagination and by the light of Pandit Labhu Ram's report, the next point we should notice is that the lenticle or cake, though of the limited size given above, is not single, but can be seen to be one of others arranged in rows or series. These follow definite lines at or near the surface; but the inference is that, below the surface by digging, we should come upon more of these lenticles, the lines of them at the surface being the projection of planes or layers of lenticles spaced apart at definite or indefinite intervals. The small amount of exploration and exploitation so far done has not yet been sufficient to settle absolutely the question of their so-to-speak broken continuity at depth (see plan of New Mines, plate 4).

The next feature of importance is that all these lenticles at the New Mines, thus spaced, are (according to Pandit Labhu Ram's investigations) set in an entirely different rock as a base. This base is an aggregate of bundles and radiating bunches of fibres of the mineral actinolite or tremolite (a pale green or white variety of amphibole) together with a few other minerals such as olivine and talc, all intermixed with one another. This actinolite-tremolite base is itself also in the form of lenses but on a much larger scale than the pegmatite, and these large lenses are distributed in their turn in crystalline limestone (marble) of which they are probably modifications. In size these huge lenses are upto several hundred feet long and from 1 to 100 feet broad. The actinolite-tremolite rock appears to be that which

has been described by La Touche as anthophyllite or kupfferite. In all the specimens examined by the writer the extinction angles under the microscope agreed better with the monoclinic amphiboles, actinolite and tremolite, than with the orthorhombic anthophyllite.

The crystalline limestone or marble runs in a thick-bedded stratum following just below the ridge crest and is one of a number of such beds regularly interstratified with other beds of biotite graphite gneiss and hornblende and garnetiferous gneiss, which together make up the solid rock of the sapphire mines area and neighbourhood.

To sum up : the 1—2 inch crystals of corundum-sapphires at the New Mines are dotted about as thick as plums in a pudding in small lenticles or disc-like bodies of kaolinised pegmatite, which again are enclosed in, or intrusive in, very much larger lenses of actinolite-tremolite rock, which again are probably local modifications of the crystalline limestone strata ; and these last along with, and interbedded with, biotite graphite and hornblende and garnetiferous gneisses, make up the rock framework of the hill-spur on which the mines are situated.

If Pandit Labhu Ram's petrological work had ended here it would still have been of importance as defining with considerable exactitude the conditions under which corundum-sapphire occurs of the kind and quantity as recently extracted in good quantity from the area of the New Mines. But Pandit Labhu Ram was able to explore more intensively than this round about the mines area and further afield, and to discover other occurrences of corundum-sapphire which will now be briefly enumerated:—

Pegmatite Veins (lenticles) North-east of the New Mines.

These veins of pegmatite in actinolite-tremolite rock are on the reverse slope of the New Mines area descending towards the Jarlang nala and 500 feet beyond the mines. The section

They pass through the ridge.

constructed by Pandit Labhu Ram through the ridge (Pl. 6) makes it likely that these are outcrops on the north-east slope of lentils belonging to the same layer or assemblage of veins as those at the New Mines situated on the south-west facing crags. The only inference possible from this is that all the connecting layer of rock, passing through the ridge and linking the two exposures together, will be found sapphire-bearing. La Touche also had mentioned large blocks of corundum-bearing granite on this slope, and Lala Joti Parshad in his report on the 1911 work had come to the same conclusion and drawn a sketch-section showing the same probable relationship between the two outcrops.

Pale pink varieties (rubies) also occur here, as well as at the New Mines and have been collected by Labhu Ram. These are vouched for by specimens, now in the Mineral Survey collection, of the rock with small crystals, about $\frac{1}{2}$ inch long, embedded in them, a single hand-specimen containing quite a number of them. As at the New Mines, dull corundum with defined parting planes is absent or rare, whilst the translucent to transparent varieties, coloured in various shades of blue and occasional pink and without any visible parting planes, are those that are commonly met with. La Touche and Mallet had previously mentioned that the colour shades into yellow brown or red occasionally.

So far as explored in small surface excavations, without any real pit-sinking, the pegmatite veins on this north-east slope have not yet been found in a kaolinised condition, and the corundum crystals are as a whole somewhat smaller than at the New Mines.

Corundum-sapphire is also found in the actinolite-tremolite rock itself.

Pegmatite Vein marked X, 300—400 feet E. of Kudi.

Here similar corundum-sapphire and pale pink varieties have been found.

Garnetiferous Gneiss, with Hornblende and Biotite.

This is marked on the map as encircling the actinolite-tremolite schist at several places, *e. g.* 100 feet S. E. of the south-west member of the New Mines, also N. of the Old Mines and probably other places along the band as marked, though it has not yet been studied in detail. Grey, blue and pink corundum is found at these places forming 10 to 20 per cent. of the inclosing rock. From some of Pandit Labhu Ram's specimens it seems that the deeper pink-tinted corundum is found near the richly biotite-bearing rock.

Pandit Labhu Ram's opinion is that many other pegmatite veins, which occur in the neighbourhood of the mines piercing the actinolite-tremolite rock, and which are not yet known to contain corundum may nevertheless be shown to contain it after further detailed search.

So much for the immediate neighbourhood of the mines; but there are other discoveries of places further away that will now be recorded.

II. — NEW NEIGHBOURING DISCOVERIES.

Hill Spur East of Dangel.

This new locality found by Mr. Labhu Ram lies 3 miles S. S. E. of the sapphire mines of Sumjam and will be found indicated on the map (Pl. 7) in lat. $33^{\circ}-24\frac{1}{2}'$, long. $76^{\circ}-24'-10''$.

The exposures occur on bare precipitous scarps at an altitude of over 11,000 feet, overlooking the pleasant well-wooded camping ground of Dangel which lies at 9,606 feet. It has only been slightly explored and no digging or sampling has been done there yet.

The corundum-sapphire appears similar to that of the Sumjam mines, but is firmly embedded in hard rock. The colour is generally blue, but in thin sections for the microscope this splits up into darker and lighter patches and strips. The darker patches, however, have the colour so concentrated that an ordinarily thin section suffers no dilution of tint, the slide presenting the appearance of being deeply stained with blue ink.

The rock formations in which the corundum-sapphire occurs are southern continuation in this direction of the three main types as found at the Sumjam mines, namely biotite gneiss with graphite, marble changing to actinolite-tremolite rock, hornblende gneiss and pegmatite and granite intrusions.

The corundum-sapphire, in 1/2 inch crystals, is sparingly distributed in a pegmatite vein 4—5 feet thick and 100 feet long and also is found in the bordering layers of garnetiferous biotite gneiss and hornblende biotite gneiss, which are from a few inches to a few feet in thickness. All these form a fringe on the eastern side of a large actinolite-tremolite mass, 250 feet long and 80 feet wide. This latter and another pegmatite vein occurring at the top of the main section were not examined for sapphire.

The sapphire found in the very thin layer of hornblende biotite gneiss, makes up 15 to 20 per cent. of the rock and is generally deeper in colour and larger in size (occasionally being 2 inches long by 1 inch wide) than that found sparingly in the pegmatite and the garnetiferous biotite gneiss.

Between the precipitous crags just described and the Bujwas nala near Dangel police post is a talus fan, forming a triangular area with its base parallel to the nala and its apex pointing to the sapphire locality. Sapphire and aquamarine in loose pieces were found here, and it is possible that it might constitute a placer deposit worth exploring.

Shasho Occurrence.

This was only cursorily examined by Labhu Ram in 1924 and again in 1927 on the way to and from the sapphire mines. The place is situated on the Kishtwar-Atholi route some 8 miles W. N. W. of Atholi, in lat. 33°-18' and long 76°-5', at an altitude of about 5,500 feet and is easily accessible. It is 24 miles south-west of the sapphire mines in a direct line.

The exposures of the matrix rock indicate an enormous mass of biotite gneiss with interbanded layers of phyllite or finer grained biotite gneiss, striking N. N. E.—S. S. W. and extending breadthwise along the road section from a point 2 miles east of Shasho to the side-stream marked Karna Na on the one-inch map, a distance across the strike of about one mile.

The gneiss is coarse and fine-grained and consists of felspar, quartz, biotite and blue and pink corundum (the latter rather rare), the felspar occurring as porphyritic crystals and eye-like lenticles. It is intruded by pegmatite veins, a few inches to one foot thick and a few feet to several feet long, which consist of microcline, quartz, a few flakes of muscovite and tourmaline. No corundum was found in the pegmatite veins examined by Labhu Ram.

The corundum is disseminated in small crystals to the extent of 10 per cent. in the hard compact gneiss. As at present known it is not likely to yield good gemstones, but the corundum may be useful as an abrasive, and further search may well reveal larger gem crystals.

The lineal extension of the matrix rock along the strike could not be studied because of the Chenab R. to the north and the steep slopes to the south. That the extension is very great to the S. S. W. is shown by the finding of loose pieces of the

corundum-bearing gneiss in the Lidrer Nala and Nai Gad some miles beyond Shasho to the west. Although details are lacking in Labhu Ram's description it would certainly seem that the corundum is not a local peculiarity in this case, but a regular constituent of the gneiss.

Hagshula, 9 miles N. by E. of Sumjam.

This locality was not visited by Labhu Ram, but is mentioned by La Touche in his published paper in the *Records (loc. cit.)*. On the southern side and close to the foot of the final ascent from the glacier to the pass (16,600 ft.) there was pointed out to him a large block of granite lying on the moraine, which contained numerous blue hexagonal crystals of sapphire, about 1 inch in diameter. None were of a good colour throughout, the blue shading into a greenish blue in places. The source of the block was evidently some part of the cliffs surrounding the head of the glacier.

General Remarks.

Although in imagination we have travelled a long way from the stocks of corundum-sapphire reposing in the Jammu treasury, and are dependent for these further evidences concerning its matrix and mode of occurrence on the report of Pt. Labhu Ram and on his maps and specimens; we are justified in coming to the conclusion that the so-called sapphire mines (as known before the Mineral Survey activities began) are not the only places where sapphire is present in the rocks of this area. We must regard the sapphire matrix as constituting, not only one or two isolated and therefore exhaustible pockets, but rather as being a continuous band of rock, shot or impregnated here and there with lenticular patches of the gemstone. This entirely different conception of its habit to which we have been led implies a very much more extended distribution of the sapphire and its matrix than has hitherto been credited; and bands of this nature among such folded metamorphic strata are apt to recur by reduplication. There may be many more such still waiting to be brought to light. These later discoveries confirm the views of the Revd.

Extended distribution of sapphire.

A. W. Heyde, Moravian missionary, quoted by La Touche in his paper, and also La Touche's own opinion that other neighbouring localities for sapphire would eventually be brought to light.

A question of some practical importance, in connection with these new discoveries, is whether we shall find some of these new lenticles and veins of pegmatite to be in the soft, kaolinised condition, comparable to that of those originally worked and from which the sapphire lumps were aptly said to be extracted "like digging potatoes", or whether it will be necessary to cut them out of the live-rock. If the latter is the case, we should only be able perhaps to operate economically on the larger crystals. For all the rest we should have to blast and roughly crush up the matrix and separate the smaller pieces of corundum by washing. It is quite likely that larger sapphire crystals will be found in larger pegmatite veins and that the larger the vein the more likely is it to have been kaolinised.

In addition to working out the corundum-sapphire occurrences in some detail as above Pt. Labhu Ram also records briefly in his report the discovery of other economic minerals in the area, namely, (1) aquamarine in certain of the pegmatites (some of which is of a rather deep blue tint though not very transparent) near Dangel and the Rubellite mine, (2) of scaly graphite in the biotite graphite gneiss, easily concentrated up to 25—30 per cent. which latter looks promising, the gneiss having large extension in the region treated of; (3) and of chalcopyrite and nickeliferous pyrrhotite in the hornblende gneiss and marble bands. Some of these will be mentioned later in this report and some have already been referred to in previously published reports of this series.

III. EXPERIMENTAL WORKING OF 'NEW MINES'
SOOMJAM IN 1927.

Method of working.

It appears, from the facts of the case and from Lala Joti Parshad's report and subsequent additions called for from him, that there

Working confined to one trench.

was no time to spare exploring for any new spots at which to excavate of a more promising nature than those at the New Mines, which had already been worked more or less successfully by Mr. Wright in 1907—1908, by Lala Jagan Nath in 1926 and by thieves during the winter of 1926—1927. L. Joti Parshad only arrived at the mines as late as 13th August and finished his excavations on 15th September.

In this short period, rendered shorter still by many days of bad weather, all the working effected was confined to one trench (No. 2 of the plan of the New Mines see Pl. 4.), along the upper and middle part of which one or two small pits were sunk down on to and through the lenticles of sapphire bearing matrix. It would have been better if the lenticles could have been approached by underground drives protected by masonry entrances and corrugated-iron gates, 6 pairs of which latter with hinges, chains and locks were prepared at head-quarters and sent up along with Lala Joti Parshad for this purpose.

Several causes, real or imaginary, conspired to prevent this method being used. Instead, simple holes in the ground were made, which were covered over at night with a wooden lid weighted with stones and protected by barbed wire. During fair weather these holes were workable; but when rain fell they became dangerous from falling stones from the steep slope above. In the early stages of clearing the trench, which is in a small stream bed, fallen blocks and rubbish had to be repeatedly blasted and removed until the weather at last moderated.

In order to enclose the working area from below the New Mines up to the ridge-summit above, barbed wire and wall fencing was erected, more as a warning against trespassers than with any idea of keeping out organised raids.

Work was begun on 15th August, but the first two weeks were interfered with by bad weather and by preliminary clearing of the ground from boulders and loose material.

Late in August (28th instant) the trench and pits struck the first (one of the A) lenticles. The Working and removing the sapphire. loads of corundum-sapphire, as excavated with the adherent tough clay matrix enclosing the crystals, were removed in gunny bags to camp at Kudi, sealed there and afterwards at convenient times were opened and the contents washed and sieved by hand. Work went on in this way and afterwards at B lenticle till 15th September, when it was closed down, partly because of the setting in of wintry weather, partly because of the unstable condition of the slope and partly because lenticle B had reached a depth of 11 feet where its base proved barren¹.

Sapphire Winnings in 1927.

We must now turn to a consideration of the washed corundum-sapphire takings. Lala Joti Parshad has estimated that, of the crude material taken from the pit, $\frac{4}{5}$ was kaolin and $\frac{1}{5}$ corundum and rock fragments. Of this last $\frac{1}{4}$ was corundum and $\frac{3}{4}$ pieces of quartz, felspar, mica and tourmaline (black variety) which were rejected. Thus the ratio of corundum-sapphire takings to crude rock as mined was 1 to 20. Pandit Labhu Ram has estimated this ratio to be 1 to 17 by weight. This means that in every lump of kaolin matrix the size of a tobacco tin one corundum-sapphire crystal of $2 \times 1 \times 1$ inches has been found. A shovelful would contain about eight crystals.

When the present writer was investigating the yield of corundum in the not dissimilar large lenticles or ovoids near Palakod in the Salem district of Madras in 1896—1897 (see *Rec. Geol. Surv.*

¹From the 6th to the 15th September the weather was fine, and the daily record of sapphire takings shows that most of them, amounting to 30,300 tolas were won during this period. Very much of this success must be attributed to the help given by Pandit Darbari Lal Sharma, B. A. (at that time head-clerk in the Mineral Survey Office, but also a man of scientific bent and attainments and an athlete as well), who had been despatched by double marches to the scene to assist in the working of the mines in case of the break-down of Lala Joti Parshad who was unwell and despondent of success.

of India Vol. XXX, Pt. 3, 1897), the percentage yield of corundum to enclosing matrix was about 4 to 100 or 1 to 25, which is not far off the ratio given above. In this case the extraction of 2,845 lbs., or 1,13,800 tolas, of corundum from about 36 tons of matrix, including charges for clearing the ground of jungle, digging and breaking up the lenticles (which were hard and solid), cost Rs. 385.

The total actual cost of labour according to Lala Joti Parshad's figures expended on the mining work, washing operations and fencing work at the corundum-sapphire lenticles of the New Mines was Rs. 550, half of this or Rs. 275 being incurred in the extraction and cleaning of the corundum-sapphire, which altogether amounted to 39,029 tolas. Thus the cost of rather similar operations at the sapphire mines was nearly twice that at Palakod for extracting equal amounts of corundum, which is probably accounted for by the much higher wages paid in the former case.

The takings in the two contrasted operations were, however, very different. The Palakod corundum was quite opaque and reddish brown in colour, although the average size and shape of the crystals were much the same as those at the New Mines, namely 2 inches by 3/4 inch. None of the material was consequently of any value as gemstone, but only as an abrasive.

I have mentioned the above comparative figures because they are not without interest from the practical as well as the scientific, point of view.

Returning to the 39,029 tolas of corundum-sapphire takings, which also included a certain amount of pickings from the loose material left by Jagan Nath's working of the previous year and by thieves operating at lenticle C and possibly at other places round about; these were weighed and sealed in bags by L. Joti Parshad and Pandit Labhu Ram in the presence of at least one police guard. They were then packed and locked in 16 wooden or leather-covered boxes. The contents of bags and boxes were registered in duplicate books under the signatures of both

officers. Eventually the whole 16 boxes were removed under guard to Jammu treasury.

On and before leaving the New Mines area the pits and trenches were filled with boulders, small stones and earth and with layers of barbed wire at intervals, the packing was believed to have been carefully done and was repeated after rain and settlement.

In spite of some set-backs which the work at the New Mines suffered under Lala Joti Parshad's management, including a certain amount of theft, the quantity of corundum-sapphire collected during about 15 working days, with the assistance of Pandit Durbari Lal, namely 39,029 tolas, contrasts well with the previous records as tabulated below:—

			New Mines.
In 1927, under L. Joti Parshad	39,029 tolas.
In 1926 „ L. Jagan Nath	5,500 tolas.
		Valley washings.	New Mines.
In 1908, under Mr. Wright*		253 tolas.	2,382 tolas.
In 1907 „ „ „		1,038 tolas.	4,394 tolas.
In 1888 „ La Touche		1,630 tolas.	

* Figures taken from *motamid's* report.

Gem-cutting Experiment.

After the return to Jammu with the 39,000 tolas of corundum-sapphire, the question arose as to what we were to do with these experimental takings. The proposal to get gem cutters from Delhi to cut a sample of the 1926 royalty stone had long been contemplated, and eventually it was decided by the then Foreign and Commerce Minister that a 5 per cent. representative sample of the whole of the 1927 takings should be cut into gems and then valued. In this way we should get a value for the whole takings and be able to estimate the commercial possibilities of the mines. Other negotiations for selling the uncut rough stone were begun, but without any conclusion being reached.

A detailed order to cut the samples was issued by the Foreign and Commerce Minister, in which funds were arranged and Mr. Joti Parshad and Mr. Hira Nand Raina were instructed to engage 1 slicer and 6 cutters from Delhi to work at Jammu for 3 months at this job. There had been many delays up to the date of this order, but at last work on the gem-cutting was begun on 10th January 1928.

There was some change of method in sampling introduced early in the proceedings, and the whole of the 5 per cent. sample was not quite finished cutting at the end, when the operations were stopped by orders of His Highness the Maharaja Bahadur, on 28th March 1928.

However, to be on the safe side by under-estimating rather than over-estimating, it may be taken that the resulting gems produced represent 5 per cent. or one-twentieth of what could be got from the whole of the 1927 takings.

The author was present at the final classifying and estimation of these gems. The lots as produced for this operation had been put up according to some system of arrangement in 5 packets as

shown below :—

List of Cut Gems made in summer of 1928.
(Mainly 1927 takings.)

	Packet.	Weight.
No. 1	88 all light coloured gems	... 135½ ratis.
	119 rather deeper coloured gems	... 123 "
	31 cabochon cut (<i>mathela</i>) (translucent and spotty)	... 226 "
No. 2	100 rather deeper coloured gems	... 103 ratis.
	76 dark coloured (indigo tint)	... 92 "
	16 (1926) find $\left\{ \begin{array}{l} 5=9 \text{ ratis} \\ 6=6 \text{ " } \\ 5=7 \text{ " } \end{array} \right.$... 22 "
No. 3	66 aquamarine gems (Daso)	... 6 tolas & 6 ratis
	24 sapphires good colour :—	
	3 large 21 small	... 16 ratis. ... 33½ "
No. 4	30 sapphires good colour and size	... 102 ratis.
	6 from operations good colour and size altogether	28 " (2 large = 13 ratis)
	10 $\left\{ \begin{array}{l} 1 \text{ large dark} \\ 9 \text{ small rather pale} \end{array} \right.$... 10 " ... 14 "
No. 5	17 gems good size (excellent colour) :—	
	15 smaller 2 large	... 38½ ratis. ... 10½ "

N. B.—(1) All Jeweller's ratis (64 ratis = 1 tola).

Therefore 1 Jeweller's rati = .93 metric carat of .2 gram.
" 1 " " = .18 gram very nearly.

Omitting from these the 66 aquamarine gems, which were cut from the remaining first quality material in the Mineral Survey collection to keep the workers employed at spare moments, and omitting also the 16 gems from the 1926 royalty takings, the remainder, slightly rearranged in places, constitute the list as below :—

Padar Sapphire (1927 takings)

Gem-cutting Results.

(on less than 5 % takings).

No. of gems.	Shade and colour.	Total weight ratis.	Average weight of each.
88	All light blue ...	135½	1½ ratis.
119	Medium shade ...	123	1 "
31	Cabochon, "Mathela cut", translucent and spotty ...	226	7⅓ "
100	Rather deep shade ...	103	1 "
76	Dark indigo shade ...	92	1⅓ "
3	Good colour ...	16	5⅓ "
21	" " ...	33½	1⅓ "
30	" " ...	102	3⅔ "
2	" " ...	13	6½ "
4	" " ...	15	3⅔ "
1	Dark Indigo ...	10	10 "
9	Light colour ...	14	1⅔ "
2	Excellent colour ...	10⅔	5⅓ "
15	Excellent colour ...	38½	2½ "
Total 501	...	932⅓	

N. B.—64 ratis=1 tola.

An analysis of these arranged in order of average weight of the gems is shown in the next list :—

No. of Gems.	Average weight of each.	Colour and shade.
1	10 ratis	Dark indigo.
2	6½ "	Good colour.
5	5⅓ "	Good to excellent colour.
4	3⅔ "	Good colour.
30	3⅔ "	Good colour.
15	2½ "	Excellent colour.
21	1⅔ "	Good colour.
9	1⅔ "	Light colour.
88	1½ "	Light colour.
76	1⅓ "	Dark indigo.
100	1 "	Rather deep colour.
119	1 "	Medium.
31	7⅓ "	Translucent and spotty Mathela (cabochon).
Total 501		

It will be seen that 501 gems of a total weight of $932\frac{1}{8}$ ratis, or $14\frac{1}{2}$ tolas, were produced. By far the greater portion namely 413 of these gems, are between 1 and 2 ratis each in weight. There are 49 gems of between 2 and 4 ratis in weight each, 5 of $5\frac{1}{3}$ in weight, 2 of $6\frac{1}{2}$ in weight and 1 of 10 ratis in weight. In addition there are 31 large imperfect stones cut *en cabochon*.

Omitting the last lot, and omitting also the 9 gems of average weight $1\frac{3}{8}$ ratis and the 88 gems of average weight $1\frac{1}{2}$ ratis, which are light blue in colour, all the remainder are mainly of good to excellent colour, the tint being a rich sky blue and sometimes very concentrated and lively. A moderate proportion of these are of a dark indigo tint including 76 of average weight $1\frac{1}{3}$ ratis and one, the largest in the collection, of 10 ratis.

This wide variation in tint has its advantages since taste and fashion are apt to change. On the whole by far the greater number are of the deep and lively blue tint that is most appreciated by purchasers because it shows up best by artificial light.

Rough estimate of value.

Until the cut gems now lying in Jammu treasury are sold or valued by experts it is not possible to do more than make a very rough estimate or guess concerning the price that the whole cutting will fetch. I have, however, put up the following calculation which is based on the assumption that 1 carat gems are valued at Rs.4 each and on the formula for larger gems which I have taken from the work on "precious stones" by W. Goodchild, Constable and Co., 1908. It is the method proposed by Schrauf for diamonds and may not accurately apply to sapphires; but in the case of our gems, which are not very large, it will probably be sufficiently nearly correct for the present purpose of getting some idea of the value of the gem output. If a be the number of carats of any one gem the formula for calculating the value of

that gem is :—

$\frac{a}{2}(a+2)$ multiplied by the value of one carat, that is $\frac{a}{2}(a+2) \times 4$ or $2a^2 + 4a$.

Applying this formula to the items in the list on page we get.

				Rupees.
1 gem of 10 ratis say	9 carats	...	$162 + 36 = 198$	
2 gems ,,	$6\frac{1}{2}$,, ,, 6 ,,	...	$2(72 + 24) = 192$	
5 ,, ,,	$5\frac{1}{3}$,, ,, 5 ,,	...	$5(50 + 20) = 350$	
4 ,, ,,	$3\frac{1}{2}$,, ,, $3\frac{1}{2}$,,	...	$4(24\frac{1}{2} + 14) = 154$	
30 ,, ,,	$3\frac{2}{3}$,, ,, 3 ,,	...	$30(18 + 12) = 900$	
15 ,, ,,	$2\frac{1}{2}$,, ,, 2 ,,	...	$15(8 + 8) = 240$	
21 ,, ,,	$1\frac{3}{8}$,, ,, $1\frac{1}{2}$,,	...	$21(4\frac{1}{2} + 6) = 220\frac{1}{2}$	
9 ,, ,,	,, ,, ,, ,,	...	$9(4\frac{1}{2} + 6) = 94\frac{1}{2}$	
88 ,, ,,	$1\frac{1}{2}$,, ,, $1\frac{1}{4}$,,	...	$88(3 + 5) = 704$	
76 ,, ,,	$1\frac{1}{3}$,, ,, 1 ,,	...	$76 \times 4 = 304$	
100 ,, ,,	1 ,, ,, 1 ,,	...	$100 \times 4 = 400$	
119 ,, ,,	1 ,, ,, 1 ,,	...	$119 \times 4 = 476$	
Total ...				4,233

All the above calculations depend in the first place on the value assigned to a gem of one carat. I have put the value low intentionally, not much above what we have realised on our rather pale aquamarines. Very likely we should get more than this. A common view is that the value of sapphire of good quality in carat size is about $\frac{2}{3}$ that of ruby, and Goodchild (quoted above) remarks "while the price of a pale ruby of one carat may only

be £ 1, a stone of deep rich colour weighing when cut one carat may fetch £ 25 or more." Rs. 4 per carat assigned in the calculations above is therefore less than $\frac{2}{3}$ of the lowest priced ruby¹.

The above sum of Rs. 4,233 multiplied by 20 will then give a rather low estimate of what we can realise on the whole output of 1927 when cut into gems, namely Rs. 84,660. The estimate is low because of the experiment being not properly finished and because a large quantity of small stuff remaining over could be cut into "Kandi" gems (less than a carat). The imported cutters did not do this work.

The actual cutting charges paid for the sample of gems made was Rs. 1,578. There were other incidental expenses arising from the importation of the cutters for a limited time into Jammu, such as travelling expenses, house rent and so on, but which we need not consider for the purpose of this experiment. They would not arise ordinarily.

We have seen in an earlier section of this report that Rs. 275 were spent in the actual labour of extracting the rough stone and the cleaning of it.

Thus the actual digging and cutting into gems of the whole output would be:—

	Rs.
Digging and cleaning the rough stone ...	275
Cutting it into gems ...	31,560
Total ...	31,835

This leaves a balance of Rs. 52,825 for maintenance, supervision, carriage and profits for a fortnight or 3 weeks actual work at the mines.

¹ Schrauf's formula is of course inaccurate for values of a near 1, because when $a=1$ the value indicated by the formula is 6 and not 4.

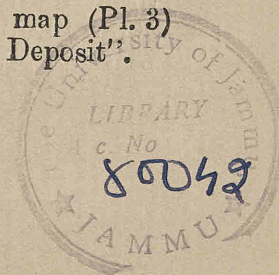
IV. OTHER INVESTIGATIONS, MINING ENGINEER'S WORK, 1928.

The Placer Deposit.

Mr. Labhu Ram was unable to make any close investigation of the placer deposit during his visits to the mine area either in 1924 or 1927, but some work was done on it in 1928 by the Mining Engineer, Mr. Zutshi which will be mentioned presently (see p. 32). This deposit had been the main source of the sapphire won during the operations undertaken by La Touche and C. M. P. Wright in the years 1887-88 and 1906-07, respectively, by digging and rough washing methods, locally improvised. La Touche in his paper in the *Records* described the locality as follows:—

"The small upland valley in which the sapphires were found is about 1,000 yards long by 400 yards broad at its lower end; the floor rises at an average angle of about 20° to the north-west narrowing to a point, and is thickly covered with loose debris fallen from the surrounding cliffs. It is from a narrow strip of this debris, averaging about 100 feet in width, along the northern side of the valley, that the sapphires are at present obtained. They appear to have been originally derived from a spot high up on the cliffs to the north of the valley, near the head of a small ravine which enters it at some distance from the apex; this accounts for their distribution along only one side of the valley".

From this description, and also from the position of the At N. E. edge of the triangular valley. La Touche's paper, it is generally clear how this 100 feet strip of debris runs. It undoubtedly follows the north-east edge of the triangular valley, skirting the foot of the grass-covered slope and rocky crags which ascend to the ridge where the rock mines are. In accordance with this description it has been approximately indicated on the map (Pl. 3) accompanying this report by the words "Old Placer Deposit".



Mr. L. Zutshi, late Mining Engineer, attached to the Mineral Survey Department, was, up to the time of writing, the last to be deputed to the sapphire mines, with the object of planning a future working of them and of advising the police regarding defensive works against raiders. This was during the summer of 1928. Part of his instructions was to "examine the placer deposit in the valley, to find out the old working ground and to trace the position of the deposit and its depth if possible with a view to future working of it".

Mr. Zutshi, accordingly (with some misgivings) made first of all about 12 excavations in the steep slope south of the "New Mines". These trenches were put about 100 feet apart and carried as far as 40 feet horizontally, but without touching solid rock in all cases. Other pits were made, 6 feet in diameter and about 12 feet deep, in the valley. No sapphire was found in the holes on the slope and only two small fragments, both less than a $\frac{1}{4}$ tola in weight, were found in two of the valley pits.

Indications of the excavations made in the slope may be seen in the photograph taken by Mr. Zutshi, which is reproduced in plate 1. It is obvious that these were certainly not within the area marked as placer deposit by La Touche, but on the steep hillside above it, so that their yielding nothing was not surprising. (Mr. Zutshi appears to have been misled by a boundary line marked on the tracing of Labhu Ram's map, which really had reference to the areas of solid rock and talus and not to the limits of the placer).

Incidentally it may be remarked that this photograph, taken by Mr. Zutshi in 1928, is of particular interest when compared with La Touche's photograph (*Rec. Geol. Surv. of India*, Vol. XXIII, pt. 2, plate 1) or with the sketch made of the latter for this report by the writer (see Pl. 2). The last-mentioned two identical views show the appearance of the rocky cliffs and slopes as they existed 40 years ago. If the photographs of La Touche and

Zutshi are closely examined it will be seen how completely they agree, even down to the scattered blocks and rock fragments which lie littering the slope¹. Forty years, therefore, in spite of frost and other agents of denudation acting energetically on the exposed scarps, have made little or no apparent difference to them or to the talus slopes. In consideration of this, one would not expect much change to have taken place since 1881 when the sapphires were first discovered, that is 47 years before the second photograph was taken. This is of importance from the point of view of recognising old landmarks, excavations, etc.

The above comments apply of course only to the slopes and rocky crags, but most probably not to the heterogeneous assemblage of debris in the bed of the little triangular valley. More extensive changes may well have taken place there, because it would naturally be a focus for the accumulation of rock fragments detached here and there from all the surrounding cliffs.

It must have been for some such reason as this that Mr. Zutshi does not appear to have noticed, or at least referred to, any traces of the old placer workings, although he describes those done by Mr. Wright from hearsay. His attempt to sample the ground met only with a very slight encouragement and any scheme for mining it that one might have expected him to propose had to give way to a scheme for further boring or deep pit sinking; and these are mainly engineering in nature. Facts concerning the true position, extent, thickness and richness of the placer deposit therefore are still wanting, before we can be said to know anything more about it than the explorations of La Touche and Wright revealed. Such knowledge might be worth obtaining in view of the obviously rolled and pebbly character of some of the sapphire takings made by Mr. Wright which the writer saw, these being quite different from the small kaolin covered crystals which characterise the New Mine area; and so, probably, were originally

¹The outline of the crags on the ridge summit would have been still more nearly alike in both cases had not a slight smoothing of it been inadvertently effected, in the reproduction of Zutshi's photograph, by the printers blocking out the sky.

derived from some other source and most likely from the Old Mine area.

It is the writer's belief that the upper end of the placer, where Upper end should be explored. it has periodically received fresh contributions of rock fragments from the area of the Old Mines, is the part best worth further exploration, and that the pitting of the slopes flanking the placer under the New Mines was a mistake, since these relatively stable slopes (as the photographs show) have existed in their present state and configuration at least as far back in time as the visits of La Touche in 1887-88, and possibly as far back as 1881 when the sapphire was first discovered.

The belief expressed above agrees with the conclusion La Touche's view. come to by La Touche during his own operations, namely, that the yield of sapphire was found by him to steadily decrease as a whole towards the lower end of the valley deposit, even though the largest stone is said to have been found from the lowest pit of all.

As bearing on the placer question, Mr. Zutshi, whilst at the Mr. Wright's canal system. mines, surveyed and described the canal system which Mr. Wright used for bringing water to wash the placer material. (Mr. La Touche when working over the same placer, some 20 years previously to Mr. Wright, has described how he had the material brought down in baskets by gangs of coolies to a spring near camp, where he washed and sluiced it with the arrangement described at p. 31). The position of this canal was first marked by Labhu Ram on the map made by him in 1924, where it is shown as crossing the ridge close to the Old Mine (see Pl. 3). The further details, and the large-scale plan of the triple canal system submitted in Mr. Zutshi's report, are useful data for those who will subsequently take up the work of washing the placer on a suitable scale. This information would have been more complete if indications had been given as to how much of the rock work, wooden flume and pillars and trestles remain intact now. It is likely that very little of anything made of wood remains.

Parenthetically it may be noted that Zutshi and others Dams across the placer. before him have credited this canal work and also the construction of wooden dams across the placer (made in order to pond back the water for operations on the placer gravel) to Mr. Wright; and probably this is to a large extent true. But in that case it is a curious thing that these wooden dams across the placer (or the lines of stones marking them) seem to be clearly discernible in La Touche's photograph *Rec. Geol. Surv. of India*. Vol. XXIII, pt. 2 Pl.1) though they have been omitted in the outline reproduction of the same given with this report. If this identification of the dams is correct—and the number, about 6, tallies with Zutshi's statement—then they were in existence in 1887, that is long before C. M. P. Wright worked the mines in 1906-1908, and they, together with some source of water, may have originally been devised and used by some of the earlier explorers of the sapphires. The dams cannot be detected in the recent views taken by Mr. Zutshi. They may well have become obliterated before his day; and, if so, these reliable evidences as to what was, and what was not, considered the placer deposit were lacking to Mr. Zutshi in 1928.

The area of the Old Mine.

Perhaps the most important point still requiring clearing Not examined or reported on by Mining Engineer. up, and one to which the Mining Engineer was directed to pay attention to in the instructions given him, was to "thoroughly explore the area of the New Mines and that of the Old Mine and intermediate places...". It is to be regretted that this officer either did not examine the two latter, or, in his report, is silent about these most important areas. Obviously when sapphire had first been got in large pieces at the Old Mine and afterwards in smaller partly coloured crystals at the New Mines, any plan for mining the area must include a close survey with cross sections of the ridge between these two classical and crucial points.

It appears that the Mining Engineer viewed with disfavour Possible reasons. the first order of Government in his list of instructions, which was to the effect that "no mining was to be done that year"—the reason for which

order being that it was not desirable to reopen the old pits and take out gemstone, thus giving opportunities to thieves to operate again in the following months, until plans and arrangements for securing the openings were ready.

Consequently the Mining Engineer declared himself scarcely justified in putting up any mining scheme at all¹. Possibly on this account he left this most important area alone. At all events it was not for want of time that he neglected it, for he had leisure to indulge in other less vital jobs that he was not called upon to do, such as picking over the debris slope below the New Mines, where a lot of very small corundum-sapphire still remained from the previous year's working, also marking timber trees for felling and dashing off to Kishtwar and back after thieves (the lost two jobs being gratuitous, since they could have been carried out by the Forest and Police officers respectively).

New Mines area.

The Mining Engineer made a few observations at the actual New Mines, but did not add anything of importance to the work done by Labhu Ram. He formulated a generalised scheme showing the lines along which development should proceed underground. This he could do, because as he explains, "the general principles governing mining of all ore-bodies are practically the same". In a succeeding chapter he discussed methods of mining the body. All these are technical engineering recommendations given in great detail and requiring the provisions of much

¹The Mining Engineer, in his report, made a grievance of the fact that on 17th August he wrote from camp for permission to reopen the New Mines, and that no notice was taken of his request. He appears to have overlooked the circumstance that, besides being contrary to specific orders of Government, it would have been impossible to get sanction and transmit it to him in time to do anything before the 21st of the following month, when the setting in of the winter snow-fall forced him to leave the mines altogether. Letter post alone took 10 days coming and 10 days returning, and the reopening would certainly have taken another week or 10 days to effect. Further comment is needless.

material in the shape of timber, building material, cement, machinery, etc. for which the Mining Engineer made no estimates. It is to be hoped that these rather elaborate methods of development and mining will be of use to whoever succeeds Mr. Zutshi in opening up the sapphire mines on commercial lines. A great deal will depend on the scale of operations adopted. Again it is possible that much simpler methods, at all events in the first instance, will be initiated, and that the next Mining Engineer who tackles the problem will set about it in a different way as regards essentials and also as regards details. In these circumstances this mineral report cannot further concern itself with what are, after all, only projects for making a beginning of mining operations at a particular spot, namely, the middle trench of the New Mines area.

Before they are finally decided on, it is necessary to urge that the ground between the New Mines and the Old Mines be carefully examined and very detail plans and sections across the ridge be drawn to scale showing specifically at what other spots openings should be made, with the object of probing the ridge for the discovery of other and perhaps larger lenticles or veins of the sapphire matrix, in continuation of those already known to exist or to have existed.

Work on a commercial basis of a tentative nature might then begin; but, in dealing with these rock mines, it should be stringently laid down that no opencast working shall be allowed and that no scheme shall be started that has not definitely made arrangements beforehand for sealing up the entrances under a ferro-concrete armour, against unauthorised raids, when the work is suspended for winter conditions or for any other cause whatever.

Mr. Zutshi's report besides dealing essentially with engineering questions of developments and mining also has set forth proposals for dealing with such questions as the washing, grading, storing of the sapphire takings, surface and underground transport, supply of labour at the mines, various constructional works such

as bungalows, police quarters, roads and a block house on the ridge near the New Mines. These are exhaustive accounts, with well illustrative plates, and, though perhaps rather too discursive, may in most or some of their details appeal to the engineer or engineers who will be eventually called upon to carry out those proposals or other similar ones.

The same remarks apply here as in an earlier paragraph, namely, that projects, as such, and as contrasted with material facts, are better omitted in this mineral report.

Mr. Zutshi, in collaboration with Colonel Gandharb Singh, Inspector-General of Police, also put up a scheme for the defence of the mines against thieves and raiders. Some such scheme was certainly urgently needed and should be valuable. But, in the opinion of the writer, all such defensive schemes will only be doubtfully affective so long as these gem-strewn areas are left unworked. The best defence of all is to systematically exploit the mines and so put temptation out of the way of petty pilferers and organised gangs of raiders from across the border.

These matters also are outside the sphere of this report to consider in any further detail. In any case they more properly belong to the Police Department to formulate and adopt.

Pickings below the New Mines.

Mr. Zutshi, during his operations in 1928, noticed that the slope below the filled-in opencast pit of the New Mines was strewn with corundum-sapphire waste, which had been rejected during the 1926 and 1927 workings. As some of this seemed to be of value, he used the discretion accorded to him to pick over this, especially at times when rain had washed the debris clean and laid bare the gemstone fragments. He also built a retaining wall to keep the debris with its possibly valuable content from sliding and finally disappearing down the slope.

After the whole of the material gathered had been washed and sorted into grades, the total collection, including a set of small samples, was found to amount to $4,516\frac{1}{4}$ tolas weight (or $4,534\frac{1}{2}$ as weighed in Jammu Treasury at the time of its disposal there). The Mining Engineer did not define the various grades into which he had sorted the material. The samples set brought to the writer by the Mining Engineer showed the fragments to be, in shape, elongated crystals or broken pieces, in size, $\frac{1}{2}$ inch by $\frac{1}{4}$ inch, in colour, grey, grey-blue and milky grey, translucent and corroded at the surface in the usual way. Only in the first grade sample were there any noticeable small patches of blue here and there, just sufficient to make the tiniest of gems ("Kandi" gems) of less than one carat each and of rather poor colour.

Marketing and other Problems.

As is invariably the case with precious stones, the successful marketing of them is a complex proceeding. The Mining Engineer in his report has not hesitated to propose definite action in this respect, and indeed to put marketing in the forefront as the most important transaction of all. He counsels the immediate creation of a sales department for this purpose. It is the opinion of the writer, however, that the most immediate duty is to obtain a rough but reliable valuation of the gems so far cut from the 5 per cent. sample of the 1927 takings.

After that a mine policy should be decided on. The mines must either be worked departmentally or a concession must be given to a private firm. The Mineral Survey is not at present equipped with men and material for working the mines; so that, if departmental working were ultimately decided on, a small but efficient Mining Department for proving and developing the known areas in the first place would have to be created.

Assuming that done, then, in order for this mining body to work conveniently, there must be erected near "Kudi", in the triangular valley, bungalows and quarters for officers and men, plans for which have already been made and passed. Even in the early stages of proving and developing the sapphire veins these will be necessary for the party at the mines, so that their stay there need not be restricted to only a month or so in the year, for want of proper shelter at night and during storms and snow-fall.

Only when the high ridge between the Old Mine and the New Mines has, next in order, been explored successfully above and below ground for the occurrence of new and perhaps good-sized lenticles or veins of the sapphire matrix (as recommended page 45-46), and when a good amount of sapphire of fairly large size has been accumulated, will the time be ripe for the establishment of a sales department, modelled probably on the lines suggested by the Mining Engineer.

The reason why the starting of a sales department is here proposed to be put later in order than as advocated by the Mining Engineer, should be obvious from two simple considerations: in the first place we must have something to sell before we engage salesmen, and secondly, any stocks of sapphire thus accumulated would do no harm. Sapphire does not deteriorate with keeping, both it and all precious stones having always been regarded as a most portable and reliable source of actual wealth, available as a world currency even when all other currencies have become depreciated. Also, some stocks we must always have in hand before sales begin.

One other point, which has been reserved to the last for emphasis, must now be touched on. When, and if, working of the mines is finally decided on, the method of conducting it by means of flying visits made during a short time in the summer must be altogether given up. In those remote regions, at 15,000 feet altitude, located not far from the border of Kashmir, and where

consequently raiders from Chamba, Pangi and Lahoul are always on the watch to carry on their poaching and smuggling traffic (with the more or less open connivance of the local people who are said to make a good thing out of it) there is only one way of dealing satisfactorily with the situation, namely, the mining party must be so constituted that it can settle down and remain there, or in the near vicinity, throughout the whole year and from year to year. Such a life will no doubt be hard, and only hardy and enterprising sportsmen should undertake it and be periodically relieved, but it should offer compensating attractions to many. No other way than actual permanent occupancy of the area will prove practicable.

Should it be that Government decides to lease out the area to a private company or companies, the matter will be much simplified. It will then only be necessary to see that sufficient checks and safeguards are inserted in the special provisions of the lease to insure that the work shall be carried on as indicated above and in other preceding paragraphs. Marketing and a sales department will then be entirely the concern of the lessees of the mine area themselves.

V. FINAL CONSIDERATIONS.

It may be well to indicate very briefly some considerations, of a general and technical nature, bearing upon the main problem of working the Soomjam Sapphire Mines. To make this working a success, the only really essential factor in the problem is the ability to collect a good supply of sapphire. Because, precious stones, like the precious metals gold and platinum, are unique in this respect that they need no complicated after-treatment, such as those of smelting, reduction and other metallurgical processes, which, in the case of most ores of the baser metals, have to be undertaken on a large scale, and at great cost with the introduction of machinery, engineering plant and skilled labour. They are also, to a large extent, independent of communications, such as

railways and graded roads, which on the contrary, are a prime necessity for the carriage of ordinary heavy and bulky minerals and their finished products. The intrinsic value of precious stones and metals is so great, indeed, that physical obstacles to their transport play a very minor part in their exploitation: any able-bodied man, for instance, would be prepared to walk the whole way from the mines to the nearest railway station, provided his pockets were lined with a dozen or so good-sized sapphires, valued at about £ 30 a carat—a small and very portable fortune.

Still, a good, fairly well graded bridle-road the whole way to the mines would be an appreciable benefit to all concerned and to others besides, and would not cost much to make.

A good bridle-road to the mines.

We may, then, dismiss from our minds all the usual incidental difficulties that beset the working of most minerals, except the simple and definite act of collecting a quantity of the gemstone. But, before we can venture on this collecting, we must be convinced that the sapphire exists, and we must know where to look and dig for it. Viewing, then, the geological facts of the area comprehensively, it may well be asked of what order of certitude is the knowledge we possess as to the abundance and accessibility of the sapphire of the Soomjam Mines.

In the first place we can be actually confident that, up to a reasonable amount, stones of the sizes and number as gathered in the experimental workings of 1927 can be collected again from the same places. But we can be morally confident of a great deal more than this. This latter statement requires a few words of explanation:—If we draw a straight line on the map connecting the Old and New Mines, and on that describe a rectangular figure towards the north-east approximating to a square, we shall find that this includes an area of about 10,000 square yards where, at the surface, there have been found several outcrops of the sapphire-bearing matrix.

Actual and moral certitudes.

Conviction that sapphire exists.

We are aware that one of these outcrops, namely that of the Old Mine, continued yielding gemstone for an appreciable time, and gave an extremely good output of very large stones from about the year 1881 to about 1987. This is a historical fact and is well known to many living people. A few specimens of sapphire then collected are still preserved, jealously guarded by the State, in the *toshakhana*, and have been seen by the writer. Of these there is at least one large piece, bigger than a polo or croquet ball, and others smaller all of a rich blue colour. There are also many cases of cut gems of pendant size which are superficially as large as florins. But of the details of the *in situ* rock occurrence whence these magnificent trophies were won we unfortunately know hardly anything, nor have we any recent descriptions by the Mineral Survey or Mining Engineer of the nature of the quarry, pits or other openings made by the early pioneers at this place. It is a curious fact that all the geological and mining men who have visited and reported on these mines, from La Touche downwards, though agreeing as to the position of the Old Mine workings, have one and all seemed to shirk any description of them. Are they rock-face workings, irregular burrowings, tunnels, pits or what, what is their extent and how deep from the surface do they go? We simply do not know! La Touche, in his published paper simply says "here the face of the rock has been laid bare by a landslip, and at first the sapphires were taken out of the granite itself: but when I visited the mines this patch of rock had ceased to yield any for some time, nor did the closest search bring any more to light". Labhu Ram in his report says "the Old Mine is also located in the same actinolite-tremolite mass that contains the New Mines..... No trace of pegmatite veins is found near it, and the mine has not yielded any stones for very many years since the late eighties". Later on in his report he discusses the point whether or not the sapphire may have had a different source altogether to that of the New Mines "having been derived either from the garnetiferous gneiss bands found exposed above and below the mine, or directly from the actinolite-tremolite schist".

None of the others who visited the mines, including the Mining Engineer, have anything to say at all on this matter.

Outcrops of sapphire matrix: Old Mine.

This is all very unsatisfactory; but at least we may conclude that very large sapphire pieces were got from this point of the rectangular area mentioned above, although details as to its matrix, mode of occurrence and the nature of the workings remain obscure.

Another of these outcrops, namely that at the New Mines, we know a good deal about, as the preceding pages of this report bear witness; and that knowledge is interesting and suggestive. The immediate matrix at the New Mines has been shown to be in a form, which, at the surface, appears chiefly as isolated but closely approximating 'lenticles' of kaolinised pegmatite. Some of these we have seen to be elongated in one direction and flattened in another and they may be either entirely separated from each other, or in some cases probably continuous below ground.

Of these known outcrops the first are those which were worked by Mr. Wright in the fallen-in working No. 1 of the plan (Pl. 4). In between this and trench No. 2 several more lenticles are to be seen indicated on Labhu Ram's map, the one marked C being one which thieves had been operating. In trench No. 2 we know certainly of lenticles A and B which were worked both by Lala Jagan Nath in 1926 and by the Mineral Survey in 1927. Lastly we know of lenticles in trench No. 3 which were worked by Lala Joti Parshad in 1911 but without much apparent success.

Now all these lenticles of the New Mines area are closely grouped together on a very steeply sloping site, not bigger than the foundations of a small house. No recognised rule has been formulated showing any particular order or arrangement of these lenticles, except that for short distances, at all events, they run in straight lines at the surface or near the surface where excavations have been made. Similarly no theory has yet been formulated to explain how the lenticles originated. But of one thing all geologists and mineralogists will be agreed upon:

that these lenticles are not the product of any surface action—that they are not superficial phenomena in any sense as regards their sapphire content though possibly so as regards the kaolinisation of the felspar. They happen to appear at the surface because they can only appear at the present surface until fresh surfaces are made by excavation. Their origin, whatever it was, must at least have been a deep-seated one.

Still another and third set of what appear to be dip-slope outcrops of these sapphire-bearing lenticles lie away on the north-east slopes. These have not been excavated as yet, but only broken away at the surface, and the lenticles do not show any change to kaolin as regards their matrix; but in other respects they appear (although somewhat irregularly) to be approximately *in situ* and similar in essentials to those at the New Mines.

Furthermore, throughout this rectangle (based on the line connecting the Old and New Mines) we know that the peculiar actinolite-tremolite rock is everywhere generally in evidence, both along the scarp and down the reverse slope to the north-east, and that it is the only rock so far known hereabouts where the pegmatite lenticles within it are sapphire-bearing.

Hence, in addition to the actual certainty that the lenticles of the New Mines and those on the north-east slope will continue some way into the hill-side and will go on yielding sapphires for a while yet, we have the very high probability, amounting to a moral certainty, that the whole extent of the area between the two and also in the direction of the Old Mine will also yield them, dispersed throughout the rock at intervals. To suppose otherwise, and argue that there is nothing to be found within and under the rest of the ridge, would be akin to refusing to believe that a plum pudding contains any more fruit than can be seen on the outside. And, in addition to the moral certainty that sapphire-bearing lenticles, at least of the quality of those found at the New Mines, will be found at other places within

the ridge covered by the 10,000 yards rectangle, there is the high probability that larger veins or lenticular bodies, more like those which presumably furnished the very rich material of the Old Mine, will also be struck. The working that has been done so far since the Old Mine was abandoned has been only very trivial, when compared with the size of the whole area believed to be productive. We have merely scratched the surface so to speak. But when steady development work shall have opened up the inside of the ridge of actinolite-tremolite rock by extensive drives systematically devised to explore its internal structure, it appears to the writer unreasonable to doubt that a fairly rich and perhaps a remarkable store of gemstone will be revealed.

Matters are not quite so satisfactory regarding the placer deposit: there cannot be any high probability in favour of it yielding sapphire now in very large quantity. More likely it has ceased to be prolific in any particular part, because its sapphire content, as proved and collected from by washing operations in the past, depended on contributions of loosened debris supplied almost simultaneously from the Old Mine area. These, however, must have ceased 40 years ago when the Old Mines gave out.

As to what happened in the years preceding the discovery of the Old Mine and whilst the sapphire matrix, though unknown, was already exposed on the crags above; and as to where all of it was dropped and covered, or was subsequently dispersed to, by the scouring action of flood and snow water at the base of the scarp, cannot well be estimated until the placer is studied more in detail. But, as previously explained (p. 34), it seems likely that the best areas to examine will be those parts of the placer high up and directly under the Old Mine, at spots just above where water action would operate most strongly.

In all other places in the triangular valley whose floor slopes at 20° according to La Touche, rapid dispersion with perhaps local concentrations here and there must have taken place. We should

certainly expect that the once rich fringe on the north-east edge of the valley deposit, and which La Touche marked on his map as placer, would have gradually worked down-hill and mingled with the rest of the valley deposit, more especially when it was receiving no fresh increments from the exhausted Old Mine outcrop.

It will hardly be advisable to neglect the placer altogether. A sharp look out should be kept for local concentrations in hollows, and the method of hydraulicking might be tried in a few favourable situations, if enough water under pressure can be arranged.

Without, then, taking into account the newly discovered and large stocks morally more distant sapphire localities (which may have great potentialities), and, without including even the placer deposit at the foot of the Soomjam mine area in our calculations, we may well consider it a moral certainty that large stocks of sapphire, and perhaps ruby, lie as yet untouched under the surface in that rectangular area lying between the Old and New Mines.

These stocks are realizable with only a moderate expenditure on tools, machinery and skilled labour; and when they become in process of realization, either by departmental or outside private activities, it ought not to be beyond our, or their, power and skill to regulate the output in accordance with modern usage and the needs of the market, as well as to develop or conserve the other outlying sapphire fields in the same way.

Thus controlled and regulated, the working of the mines on practical commercial lines should prove an immediately feasible mineral industry to start; one that will require few elaborate arrangements as compared with many other metal and mineral propositions; one that is intrinsically very valuable as to its output (which output is easily stored, transported and manipulated); and one that can augment its sphere of action by including a gem-cutting industry if thought desirable.

All these subsequent proceedings, however, being strictly commercial in their nature, need no further remarks here in this mainly mineral and geological report.

VI. SAPPHIRE SAID TO COME FROM NEAR LEH.

One other occurrence of sapphire may be mentioned here, because, although the exact locality is unknown, the specimens indicate by their appearance and habit that they have had a source other than that of the ordinary Padar sapphire.

The specimens were brought to the writer's camp in March 1921, by a Brahman villager named Bhikku, of Nagrota

How obtained. Gujru, Kathua district, Jammu Province; who stated that they were given him several years before by Abdulla, a native of a village some 25 miles from Leh who in turn had said that they came from a stream-bed some 2 or 3 days journey from Leh.

The collection consists of a small handfull of sapphire gravel, the individual pebbles being about the size of small peas, fairly uniform and resembling small shingle. The extreme amount of variation is between granules weighing $\frac{1}{2}$ carat and 2 carats respectively. All the pieces are sub-angular with water-worn, smooth edges, except where recent fracture has supervened. Their colour by ordinary reflected light is a deep rich blue, almost enamel-like, particularly as modified by the weathered and water-worn surface skin of the pieces. Some of the angularities can readily be seen to be due to original crystal faces, others to fracture of what were more or less rounded pebbles or irregular pieces.

Among the few pieces showing crystal faces one can identify examples with prism faces and basal planes well developed, and, less well developed, the rhombohedron faces appearing as small truncations of the alternate solid angles where the basal plane

and prism edges meet. But there is no special development of the latter so as to give the hexagonal bi-pyramidal effect which characterises the Padar sapphire. In specific gravity and hardness the pieces agree with typical corundum.

Most of the pieces, allowing for surface weathering, appear to be semi-transparent to transparent, and this is borne out by the five pieces which were cut into small gems at Delhi.

Examined more in detail by transmitted light, some of the more transparent pieces show a colour that is fairly deep blue in certain directions or parts of crystals, whilst in others a shade of a pale greenish-yellow becomes evident. Some are noticeably parti-coloured, a small rich blue patch appearing within a pale light-blue or greenish-yellow portion.

Examination with a dichroscope shows the colour variation to be due to rays vibrating at right-angles to the vertical crystallographic axis being deep blue and those parallel to that axis a pale greenish-yellow.

The sample gems prepared from this material vary from a deep rich blue to a greenish blue and seem fairly attractive, though very small, being less than a carat each in weight. None of these have the cold indigo tint or the bright azure blue of the Padar stones.

Two attempts in 1921-22 were made, with the help of Bhikku, to trace the sapphire pebbles to their source; but without any success. On the second occasion, Mr. Joti Parshad conducted the investigations himself incognito, travelling ostensibly as a merchant. The Chamba authorities stopped him going through their State; so he proceeded as far as Kulu, sending Bhikku ahead to Lahoul. Nothing came of the latter's efforts, no more specimens were obtained, Abdulla could not be traced and no more information as to where the stones came from was forthcoming.

From enquiries made and sapphire seen in the bazars of Kulu and, after much secret talk and chaffering, Joti Parshad considered it proved that :—

- (1) Sapphire is brought for sale to Chamba and Kulu and handed over to shopkeepers only, who act as middlemen to the prospective purchasers.
- (2) Pebbles of sapphire, like those of Bhikku, are sometimes also brought by the same men in the same packets along with ordinary Padar sapphire.
- (3) Sapphires from Ladak (Leh) have never been heard of in those parts.
- (4) The sapphires are brought by Pangri, Lahoul and Bushahr people via Chamba and Kulu.

On the whole Joti Parshad concluded that the Bhikku pebbles came from somewhere in Padar district such as Hagshula. In view of the subsequent investigations made by Labhu Ram and the fresh places for sapphire and corundum actually discovered and recorded by him at Dangel and Shasho, there is no longer any object in speculating or guessing where the Bhikku stones came from, nor any profit to be derived in spending any further time and efforts to trace them. They may have come from anywhere.

BERYL AND AQUAMARINE.

Daso, Baltistan.

A full account of the gem form of this mineral, as occurring at Daso on the Braldu R. in Baltistan (lat. 35°-43', long. 75°-31'), has already been published in the *Records, Geological Survey of India*, Vol. XLIX, pt. 3, 1918, giving details of the experi-

mental work done on it by Mr. Joti Parshad (the original discoverer) and the present writer, during the summers of 1915-1917. Since then the mine area, except that it was leased out to a private firm for one season, has remained unworked.

Gems cut by Delhi craftsmen, from the proceeds of the 1917 operations and from the royalty realised in kind from the last working, were shown in the Kashmir Court at the Empire Exhibition at Wembley in 1924; and, on that occasion and when other experimental sales were made to a few interested people, these semi-precious gems were much admired and sought after. Flawless varieties were sold uniformly at the rate of Rs. 3-12-0 or 5 shillings a carat. The cold, steely blue-green colours and the good lustre and brilliance of the larger pendant forms of this gem (which show up well in artificial light) rendered it a favourite among connoisseurs and overseas visitors to Wembley.

Other Localities.

Since the above occurrence of aquamarine was investigated more examples of this pleasing stone have turned up at a number of other places, enclosed in the usual way in a pegmatite matrix. No detailed tests have been made of the yield or quality of these new finds, which have only been examined superficially during the course of other more urgent investigations. These localities are :—

(1) Sapphire Mines, Soomjam, (2) Dangel sapphire locality, as inferred from loose pieces of the matrix with aquamarine, in them, found by Labhu Ram below the sapphire locality. Some of these pieces enclosed aquamarine of a much darker blue (approaching that of sapphire) than that of the typical aquamarine of Daso; but so far, only in semi-translucent pieces. From the fact that in other localities the common translucent beryl always possesses the same colours as the rarer transparent gem form found along with it, it is reasonable to expect that, when these dark blue beryls are tracked to the parent rock, there will be found here and there transparent gem-forms possessing the much prized corn-flower blue tint. For details as to

these two localities, the references under "sapphire" may be consulted, and also the maps, plates 3 and 7.

3) In a pegmatite vein exposed on the bare rugged hill slopes $1\frac{1}{2}$ miles north of Kaban (lat. $33^{\circ}-17'$, long $76^{\circ}-16'$), which is a small village situated on a tributary of the Chandar Bhaga river and joining the latter some few miles above Arthal (Atholi). This vein cuts across the W. N. W.—E. S. E. strike of the Muth quartzite in a N.—S. direction, being 20 feet long and 10 feet wide, as exposed at the surface. The vein of pegmatite is coarse-grained centrally and finer grained towards the margins. Muscovite mica, in plates 3—4 inches across, and black tourmaline occur in the central portion, together with beryl and aquamarine. The finer-grained margin is bounded by a narrow border of foliated mica schist, in which respect the latter resembles the mica schist bounding the sapphire-bearing pegmatite of the Soomjam New Mines (see p. 15). Labhu Ram, who made this cursory investigation during his journey towards the Sapphire Mines, had not time to open up the exposures: he merely collected a few specimens of aquamarine and beryl at the surface, all of which are pale and transparent to translucent.

(4) Another vein of pegmatite, $1\frac{1}{2}$ miles N. N. E. of Kaban (lat. $33^{\circ}-16'-43''$, long. $76^{\circ}-16'-25''$), which is 10 feet long and 3 feet wide, is quite similar in all respects to the first-described, except that only rough beryl fragments were collected from here.

(5) A third similar vein was found 2 miles N. W. by N. of Hamur (lat. $33^{\circ}-24'-8''$, long. $76^{\circ}-19'-13''$). It is 20 feet long, 5 feet wide and it also yielded only some rough beryl. Labhu Ram states that Wazir Zorawar, General Baz Singh, Major Balak Ram, Mr. Wright and the agent of Sohnu Shah (all of whom worked the Sapphire Mines at various times) are said to have visited this place and appear to have done much blasting work there. Probably they hoped to find more sapphire there.

(6) Still other pegmatite veins are to be seen in the neighbourhood that Labhu Ram had not time to visit.

(7) Aquamarine was also collected by Labhu Ram 1 mile W. by S. of Chishote (lat. $33^{\circ}-22'$, long. $76^{\circ}-16'$).
Near Chishote.

When we consider that the places for aquamarine which have so far been discovered lie along main routes and that they have only been come upon during journeys made with other objects, the impression given is that these elevated mountainous regions must contain many more examples of gem-bearing veins which however, still remain undetected and undescribed. Their wide distribution in the area is therefore as probable as that of the corundum-sapphire veins.

RUBELLITE AND GREEN TOURMALINE.

A few fine crystals of rubellite, up to 3 inches in length and from 1 inch to 2 inches in breadth, are in the collection of the Mineral Survey, having been obtained by Joti Parshad during his early years of work at the Sapphire Mines. These presumably came from the locality marked "rubellite mine" on the detailed plan (Pl. 3). In his brief sketch of the minerals found in the State, however, Joti Parshad writes of the rubellite locality as being "7 miles from the Sapphire Mines". Since the locality marked on the map is only about 250 yards distant from the Old Sapphire Mine, and at only 300 feet greater elevation, it is difficult to understand the distance being given as 7 miles. That the place as marked on the map was in 1927 accepted as the rubellite mine by everyone of the party, including Joti Parshad, is made evident by the latter's diary and by further attempts made to explore the rubellite. Pandit Darbari Lal was sent there for that purpose, but found the bowl-like depression of the mine so full of snow and ice that it would have been impossible to clear it in the short time left to the party for the sapphire operations.

The colour of the rubellite specimens is generally the tint of pomegranate or red currant juice in various shades. One small specimen is of much deeper colour and partly clear; but all the others are full of flaws and feathers and would at the best make tiny gems here and there of 1—2 carats. Some pieces have a yellowish-green core running along the main crystallographic axis and fading away into the pink of the rest of the crystal.

Green tourmaline occurs as a number of slender prisms $\frac{1}{8}$ inch thick and one inch or so long penetrating vein quartz, and of a deep clear green colour. The specimens of this mineral appear to have come from the other side of the valley north-east of the Sapphire Mines. La Touche refers to them in his published report on the mines as being found "in a granite vein 1 mile from the Sapphire Mines".

Other references by La Touche to the minerals spodumene and prehnite, found in loose pieces in the valley to the north of the mines, make it clear, however, that that also was the direction of the green tourmaline occurrence.

Some of the better pieces of the rubellite and the acicular green tourmaline were cut by Delhi lapidaries for the Wembley Exhibition into a number of very small gems—"Kandi" gems (see p. 30) of less than a carat weight. Though so very small, they made effective little stones, the colours being rich and complimentary to one another, and almost as pleasing as rubies and emeralds.

QUARTZ (ROCK CRYSTAL) AND FELSPAR.

As would naturally be expected, large and clear crystals of quartz, both colourless and of the dark, smoky or cairngorm variety are also found in the pegmatites and drusy cavities of the rocks of the higher mountainous parts.

Most of these in the collection of the Mineral Survey were obtained by Mr. Joti Parshad during his earlier expeditions, or were brought to him by enterprising villagers. Many of these, which in size are from a few inches long to others weighing from 8 to 10 lbs., came according to Joti Parshad's reports, from the Padar and Kishtwar hills, others from the Basha and Braldu valleys, which valleys unite to form the Shigar valley a little below the aquamarine locality of Daso. A specimen of rather pale rose quartz is stated to have come from Kuardo, a village a few miles north of Skardo (lat. $35^{\circ}-18'$, long. $75^{\circ}-38'$).

Several large crystals of smoky quartz, including one foot long by 8 inches broad and weighing, 25 lbs. were brought into the writers camp by the villagers of Tarkutta (lat. $34^{\circ}-48'$, long. $76^{\circ}-12'$) during the 1917 expedition to the Daso mines. They were said to have been gathered from the neighbouring nalas. Some of these were cut up into buttons, ear-drops and gems and looked very well.

Other uses that quartz crystals have now are connected with the piezo-electric phenomena which they exhibit under certain conditions. A modern demand for these has arisen because of their use for controlling the frequency of waves emitted from Broadcasting Stations¹. Possibly some of the larger quartz crystals obtainable from the above sources might answer the necessary conditions. Unfortunately the sources are irregular and scattered and it might be difficult or impossible to get selection of the right kind done by the hardy mountaineers of these regions, who alone know and can penetrate to their distant rocky fastnesses.

¹For this purpose the crystals should be 4 inches long or over, clear and without cracks, with straight continuous striae on the prism faces and without any evidences of twinning—as shown by the x and s facets, appearing only on alternate corners of the prism faces, by the regularity of the etched figures, and by the absence of variations in the degree of polish on the crystal faces.

The felspar group of minerals, which include such well known forms as moonstone and labradorite, is only represented, so far as at present known in Jammu and Kashmir, by one mineral species, namely the variety of microcline that goes by the inappropriate name of amazon-stone.

Specimens of this were collected by Mr. Joti Parshad from the pegmatite veins of Chishote (lat. 33°-22', long. 76°-16'). Its claim to a place among the semi-precious gemstones is solely due to its colour which is a pale blue-green (almost turquoise) tint; for otherwise this stone is entirely opaque. It occurs in rather large well crystallised masses which can be cut up and polished into beads and other small objects¹.

SERPENTINE.

Shigar.

The old workings for the above near Shigar (wrongly referred to in Ball's Economic Manual, p. 487, as Shigri) were visited by Lala Joti Parshad in 1912. He has described in his manuscript reports the two chief localities as being in lat. 35°-27', long. 75°-55' (corrected) and lat. 35°-26½', long. 75°-53' (corrected). These points, when plotted on the Survey of India degree sheet No. 43M (Provisional Issue), are seen to be high up the Yalsta Loomba, a tributary stream which joins the Baumaharel stream some 7 or 8 miles above Shigar. Joti Parshad has given the height as from 18,000 to 18,500 feet, but this estimate is probably too high.

¹In addition to the above translucent lumps of pale green and rose-pink fluorite, respectively from the pegmatite veins of Chishote and from the Goyongonala (lat. 35°-41', long. 75°-35') near Skardu, are in the collection of the Mineral Survey. These, by reason of their colour and translucency, may perhaps be included with the semi-precious stones; but the Chishote occurrence has been briefly mentioned in the printed report on the Non-metallic Minerals, p. 51, where it more properly belongs because of its other uses. It is a mineral of rare occurrence in India.

The serpentine is rather vaguely described as occurring in large or enormous masses, bedded with or lying along the bedding of the surrounding rocks, which are said to be of metamorphic origin and much folded, with many fold-faults and broken anticlines. Its origin is considered to be probably from basic igneous rocks by alteration.

The colour (as is well known from specimens and articles made from the serpentine) is a semi-translucent apple-green, varying to sulphur-yellow, grass-green and dark green.

Asbestos (Chrysotile, or the fibrous form of serpentine) and steatite are found associated with the serpentine in veins or lenticular bodies. Other minerals enclosed in it are said to be biotite, magnetite and calcite.

Owing to the great height, the mines can only be worked in August—September when the snow has disappeared. They were not working when Joti Parshad visited them.

There has for long been a small trade in articles, such as cups, bowls, dishes, tumblers, tobacco pipes, teapots, etc., made from this serpentine. These are familiar to all visitors to Kashmir as being on sale in the bazars. The belief is current that medical and other virtues attach to liquids drunk from vessels made of this material. Hence the local name for it of "Zehr mohura" (poison detector) and the enhanced value attaching thereto. Hence also probably the rather surprising fact that no attempts seem ever to have been made to produce carved figures or other ornamental designs from it, for which purpose it would undoubtedly be well adopted.

The right to work the mines is usually leased out by auction each year, the royalty realised being now about Rs. 1/6 per maund,

with limiting reservations as to the amount to be mined in one year, and the stipulation that large and flawless pieces over a certain size be considered to be the property of the State.

At present the quantity put on the market is very small, 50 maunds only in 1928; the demand for teapots and cups falling off in favour of the more convenient imported China ware, and the belief in its medical and magical properties likewise probably diminishing.

Other Localities.

Other not very important occurrences of serpentine, of mottled and veined dark and light green, have been noted by the writer at many places, such as near Dras in connection with the olivine chromite rock (dunite) of that place (lat. $34^{\circ}26'$, long. $75^{\circ}44'$), Tashgam (lat. $34^{\circ}30'$, long. $75^{\circ}56'$) near the bridge across the Dras river, similarly in connection with dunite and other peridotite masses, and in less abundance at Pashkim (lat. $34^{\circ}31'$, long. $76^{\circ}12'$). No red tints have been seen in these serpentines.

Small pieces, big enough for paper weights, can be obtained easily, and they take a fine polish and look very handsome. Larger pieces are more difficult to obtain, not because of the scarcity of material (which is there in abundance) but because of the cracks and fissures in the rock—the evidence of intense crushing that the formations have suffered since they were formed. Were these places not so far away from civilization, some of these serpentines might be carved into curios and find a market; but, not having any traditional backing of magical properties, such as the Shigar "Zehr mohura" possesses, they might well find no demand at present among the peoples of Kashmir.

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