THE GEM COLLECTION OF THE RIJKSMUSEUM VAN GEOLOGIE EN MINERALOGIE OF LEIDEN

THE PERIDOTS

by

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Introduction.

The peridots in the gem collection of our Museum were acquired a long time ago (part of them were from the collection of King William I of the Netherlands).

We should be sceptical about data on the origin of this material. Firstly we do not generally know whether the stones were bought or received as a gift; we learned by experience that a person giving material (often a layman) will not be too precise when stating the locality especially as he will not see its importance. Moreover in the last century scientists could not realize yet how valuable an accurate description of the locality would be nowadays. For they did not think of the possibility that samples of one mineral from various localities might have different properties (of course they did not yet know the importance of an investigation as to the nature of inclusions). Besides in cataloguing small objects (such as gemstones) systems were used which did not rule out mistakes, so that a recent investigation of old material may present difficulties as to the definite locality.

According to data given the peridots we intend to describe here would be from Upper Egypt, Brazil, Peru and Siberia; in addition there are some whose locality is unknown. In recent literature on gemstones Upper Egypt and Brazil are always mentioned as peridot localities, so these data on the material will be correct.

It is somewhat different with the occurrence of peridot in Siberia: in gemstone literature of recent years Siberia is not given as a locality. But one may find it in older works; ESCARD (1914) e. g. states on p. 202: "Les péridots destinés à la joaillerie viennent surtout de l'Oural, du Brésil, de la Perse, du Mexique et de l'Egypte". So the possibility is that the peridots from Siberia in our collection were originally found in the Ural mountains. Of course no attention is paid in this article to the so-called "Siberian-chrysolite" (an incorrect name for demantoid garnet) also mentioned in recent literature.

Not a single work on gemstones gives Peru as a peridot locality; STEINMANN (1929) describes some gemstones that are found there, but does not mention peridot. It would not seem unlikely, though, that the peridots in our collection, which are said to be from Peru, were found near Pegu; this latter locality is given fairly commonly, also in older literature. Thus

GROTH (1887) gives Pegu as a peridot locality, BAUER (1932) also mentions Pegu, "das Land der Burmanen".

With the peridots whose locality was stated to be unknown an original label was found saying: "Péridot vert et vert jaunâtre, de l'Orient". Seeing that BAUER (1932) gives "der Orient" as a peridot locality and, as was said above, ESCARD (1914) speaks of Persia, the peridots in question may well be from Persia.

Moreover it should be mentioned that in this paper only the gemmological name peridot is used so as to prevent confusion with other terms.

The refractive indices were measured on a RAYNER refractometer by means of sodium light or with the aid of immersion liquids in the case of some rough crystals and a few small cut stones with slightly domed facets.

The specific gravity of the stones was determined by hydrostatic weighing, ethylene dibromide being used as an immersion liquid.

The spectroscopic investigation was carried out with a HARTRIDGE reversion spectroscope and a BECK wavelength instrument.

Description of the peridots.

1. *Upper Egypt.*

From this locality two crystals are present in the collection (Nos. 696 and 697); so there are no cut stones. Both crystals are light oil-green in colour and transparent. They are not very big, weighing 4.22 and 4.99 carats respectively; if we take into account that crystals of up to 80 carats are known from this locality (according to HERBERT SMITH, 1940) it is clear that the crystals in question cannot be considered rare as regards size. The shape of the crystal may be called normal for both.

No. 696 has well developed prism faces, especially (100) and (010). Also present are the faces (021), ($0\bar{2}1$), (101), ($\bar{1}01$), (111), ($\bar{1}11$), ($\bar{1}\bar{1}1$) and ($1\bar{1}1$). No faces are to be seen at the "bottom" of the crystal, part of it having been broken off.

No. 697 also shows well shaped prism faces (100) and (010), as well as (021) and (111) faces stretched parallel to the b-axis; this crystal too, has been broken off at the bottom and shows conchoidal surfaces of fracture. Both crystals are striated parallel to the c-axis.

The specific gravity of No. 696 is 3.327, of No. 697 it is 3.345; for the refractive index of either crystal 1.67 was measured. The latter observations were made by an immersion method, the whole crystal being immersed, so no powder was used. This value of the refractive index more or less corresponds with the one of N_γ. Besides both crystals show a distinct pleochroism (yellow-green and green).

They also have a characteristic absorption spectrum. One can clearly see three bands in the blue. Firstly a fairly broad band centred at 4933 Å; this band has the highest intensity near 4970 Å. Further a rather sharp band at 4728 Å and finally a somewhat vaguer band at 4530 Å.

Both crystals contain numerous inclusions of hexagonal-shaped brown flakes (see fig. 1); according to GÜBELIN (1953) these are biotite inclusions characteristic for peridot from St. John's Island. The flakes occur in groups, sometimes as "mica books" and are oriented parallel to the crystallographic c-axis of the crystal. They are also found in zonal orientation, so that we may conclude they are of primary origin.

2. *Brazil.*

From this locality there are in total one rough crystal and three cut stones in the collection. The rough crystal (No. 699) has an oil-green colour and is darker than the two crystals from Egypt described above. The crystal is transparent and weighs 5.96 carats. The crystal faces are well developed, the prism faces (100) and ($\bar{1}$00) are striated vertically. The face (010) is clearly present. Further there are the faces (021), (0$\bar{2}$1), (111), ($\bar{1}$11), (1$\bar{1}$1),, (101), ($\bar{1}$01), (110) and ($\bar{1}$10). The bottom of the crystal has been

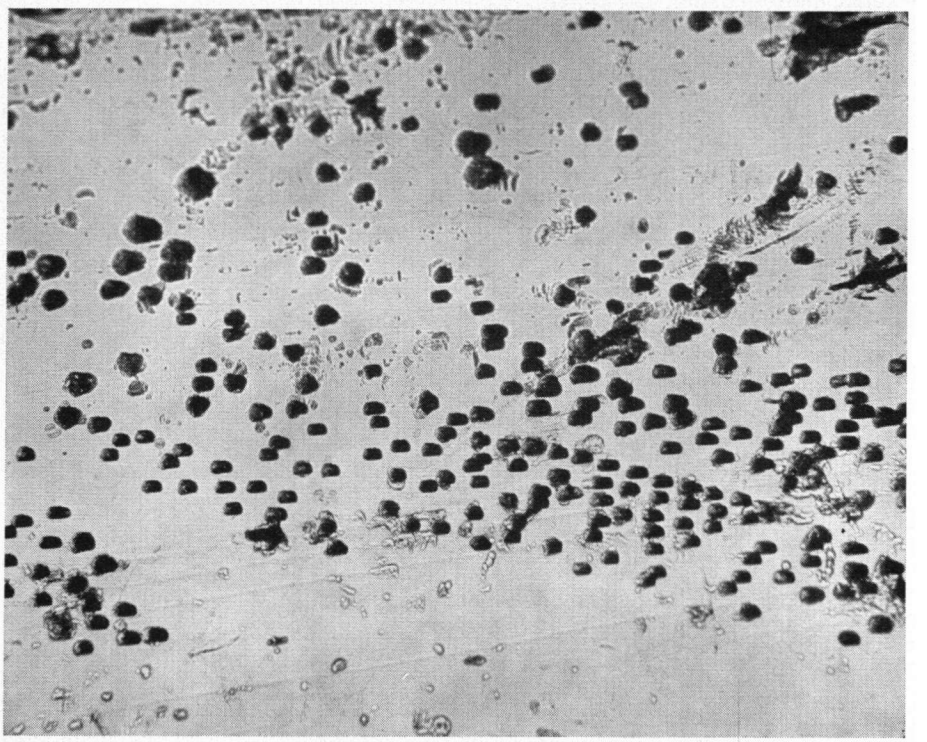

Fig. 1. Mica flakes in peridot No. 697 (× 100)

broken off and shows conchoidal surfaces of fracture. Its S. G. is 3.339, its N_γ about 1.67. The crystal clearly shows pleochroism (yellow-green and green). The absorption spectrum shows bands on 4930, 4734 and 4530 Å in the blue.

The crystal contains numerous droplike inclusions with brown cores; these inclusions occur in groups (see fig. 2) and as crystal feathers. GÜBELIN (1953) describes similar inclusions in peridots from Hawaii. He takes the brown material to be limonite or fayalite; with the stone in question we cannot be sure of this. It is evident, however, that they are primary inclusions.

The three cut stones (Nos. 732, 733 and 734) have a pale yellow-green colour and are trap cut. They have a weak pleochroism in tones of yellow-green and green.

No. 732 weighs 0.50 carats, the size is 6.2 × 4.3 × 2.1 millimeters. It is a transparent stone and the edges of its facets are much worn. The specific gravity is 3.354. The refractive indices could not be measured accurately as the table is not smooth enough. A reading with the so-called "distant vision method" gave 1.67, which more or less corresponds with the value for N_y. The stone contains no diagnostic inclusions.

The absorption spectrum shows four bands in the blue part at 4968, 4933, 4734 and 4530 Å. All these bands are rather weak, which will be due to the less intensive colour of the stone.

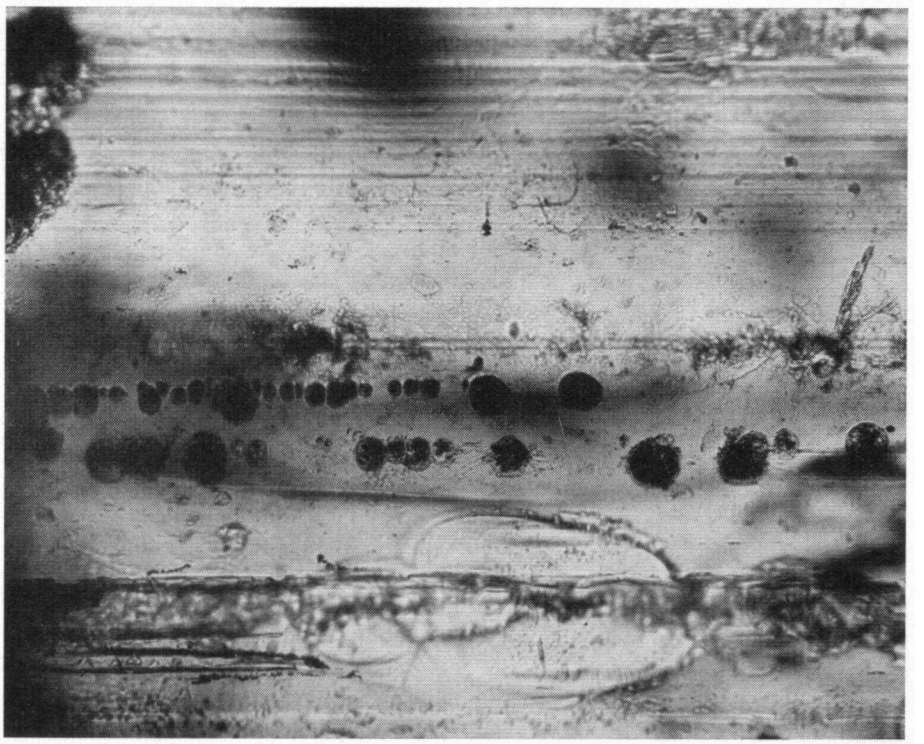

Fig. 2. Droplike inclusions in peridot No. 699 (× 100)

No. 733 has about the same appearance as the stone just described. Its weight is 0.86 carats, the size is 6.9 × 5.8 × 2.8 millimeters. This transparent stone seems worn. Its S. G. is 3.341. The refractive indices cannot be measured normally for the same reason as with No. 732; a value of 1.67 was read. This stone does not contain any diagnostic inclusions either.

The absorption spectrum is weak but shows distinct bands in the blue at 4965, 4931, 4732 and 4528 Å.

No. 734 weighs 0.54 carats, its size is 5.9 × 5.1 × 2.1 millimeters. The stone is transparent and badly damaged in some places. The S. G. is 3.357; measured with the distant vision method it has a refractive index at 1.65.

This stone has no inclusions worth describing. Just as for the Nos. 732 and 733 this stone has a weak but clearly recognizable absorption spectrum. Bands at 4975, 4926, 4734 and 4531 Å may be seen in the blue part of the spectrum.

From the above data it is seen that the cut stones from Brazil in the collection are only small and not very fine. This might also be due to their having been cut a long time ago.

3. *Pegu (Collection King William I of the Netherlands).*

From this locality there are five stones in the collection (Nos. 701, 702, 709, 714 and 757).

No. 701 has a clear oil-green colour and is highly transparent. It is mixed cut with an oval outline and has a table which is slightly domed. Its weight is 7.06 carats, its size 14.4 × 11.7 × 5.3 millimeters. The S. G. is 3.347.

A refractometer reading could not be carried out on the table. Therefore it was done on one of the back facets; the result was N_z' is 1.690 and N_x' is 1.658. The pleochroism is distinct in tones of yellow-green and green. Owing to the strong double refraction one may see doubling of the back facets when viewing through the table with a pocket lens.

No diagnostic inclusions are to be seen, only some cracks filled with air, so iridescence may be observed.

The absorption spectrum is typical for peridot; it is a distinct spectrum with bands at 4970, 4935, 4726 and 4531 Å.

No. 702 is one of the finest peridots of the whole collection. Its colour is a very clear oil-green. The stone is only very slightly damaged and is trap cut. Its weight is 23.17 carats, its size 20.5 × 18.5 × 7.3 millimeters. The specific gravity is 3.346.

The refractive indices, measured on one of the back facets because the table is domed, appeared to be N_z' is 1.688 and N_x' is 1.658. The strong double refraction may be seen with a pocket lens. The pleochroism is weak. The stone is very "clean", there are no inclusions to be observed.

As may be expected, the absorption spectrum shows some bands in the blue at 4970, 4934, 4731 and 4532 Å.

No. 709 is a transparent mixed cut stone with an oval outline, the table is slightly domed. Its colour is yellow-green. The size is 10.4 × 9.5 × 4.1 millimeters, the weight 2.93 carats. The specific gravity was measured as 3.348.

The refractive indices measured on one of the back facets are 1.689 and 1.658. Its double refraction may be observed with a pocket lens. The stone has a distinct pleochroism in yellow-green and green and contains two phase inclusions lying in one plane, which probably are of secondary origin.

In the blue part of the absorption spectrum one may see some bands at 4969, 4930, 4725 and 4528 Å.

No. 714 is the largest peridot of the collection. It is cut in a trap-like style with a number of extra facets at the back. Its size is 22.7 × 19.0 × 7.9 millimeters, the weight is 31.66 carats. This transparent stone has a rather dark olive-green colour. Its specific gravity is 3.347.

The refractive indices observed on the table are $N_z' = 1.685$ and $N_x' = 1.650$.

The birefringence (0.035), in this case, is nearly the maximal value for peridot. The pleochroism is very distinct in tones of yellow-green and green.

The absorption spectrum shows a vague band in the red part at 6342 Å, which will be due to chromium. ANDERSON and PAYNE (1955) state the possibility of chromium lines in the spectrum of peridots from Hawaii. Anyway the peridot in question may well contain so much chromium that it is shown by the absorption spectrum. Further one may observe the bands due to iron in the blue part of the spectrum at 4965, 4934, 4732 and 4524 Å.

This large stone contains one crystal feather as a healed fissure. This fissure shows numerous negative crystals and more or less rounded forms. Both these forms are filled with two phases. The fissure has a tell-tale pattern as it is filled with larger inclusions surrounded by a collar of smaller inclusions in the thinner part where the remedial action began. It is therefore of secondary origin, the more so as it is connected with the exterior of the stone. GÜBELIN (1957) already reported this kind of healed fissures for a great number of gemstones.

Peridot No. 757 is particularly clear, transparent and undamaged. Its colour is a lively oil-green. It is a mixed cut stone with a weight of 6.89 carats and a size of 14.6 × 10.6 × 5.7 millimeters. The table facet is slightly domed and the outline of the stone is oval. The S. G. of this peridot is 3.347.

The refractive indices measured on one of the back facets are $N_z' = 1.690$ and $N_x' = 1.655$. Doubling of the back facets may be observed when viewed through the table with a pocket lens. The pleochroism in yellow-green and green is distinct.

No diagnostic inclusions are to be found. In the blue part of the absorption spectrum four bands occur at 4970, 4933, 4734 and 4532 Å.

4. *Siberia.*

There are 18 cut peridots in all from this locality in the collection. Ten of them are from the collection of King William I of the Netherlands. All the stones are rather small. First the eight stones will be described which did not originally belong to His Majesty's collection. These are Nos.: 698, 715, 717, 718, 719, 720, 729 and 730. After that the other stones from this locality will be dealt with.

No. 698 has a pale oil-green colour and is trap cut. Its table is rather large, the facet edges are damaged; in some places conchoidal fractures may be observed. The size of this transparent stone is 6.0 × 4.8 × 2.6 millimeters, its weight 0.71 carats. The specific gravity is 3.347, the refractive indices, measured on the table are $N_z' = 1.688$ and $N_x' = 1.657$. The stone has a weak pleochroism in yellow-green and green.

By spectroscopic inspection one may see bands at 4930, 4740 and 4530 Å in the blue part of the spectrum.

Secondary inclusions are present in the stone; a healed fissure, consisting of negative crystals and somewhat rounded forms filled with two phases, is connected with the exterior of the stone and is not arranged parallel to any crystallographic direction.

No. 715 is a pale green transparent stone, partly cut and partly rough. It is a specimen with three very small polished planes. The rest does not

show any crystal faces but conchoidal fractures may be observed. The weight of this stone is 0.27 carats, the size 4.6 × 3.2 × 3.0 millimeters. Its S. G. is 3.338, the mean refractive index is about 1.67. The pleochroism is very weak, a normal birefringence may be seen.

In the absorption spectrum some weak bands at 4968 and 4932 Å in the blue part are observed.

Finally no diagnostic inclusions are present in this specimen.

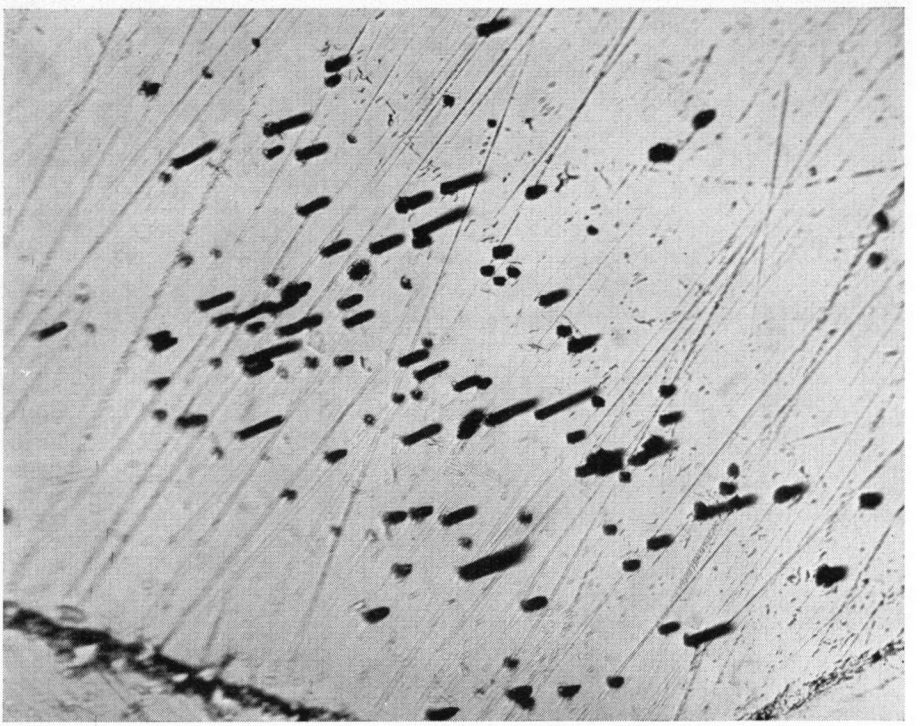

Fig. 3. Mineral inclusions in peridot No. 717 (× 100)

No. 717 is a trap cut, pale yellow green, transparent stone. At one of the corners a part has been broken off, the fracture is conchoidal. Its weight is 0.77 carats, the size is 6.7 × 5.2 × 2.7 millimeters. The specific gravity is 3.348.

The stone has a weak pleochroism, the refractive indices measured on the table are $N_z' = 1.689$ and $N_x' = 1.662$. By spectroscopic investigation a few bands in the blue part of the spectrum may be observed at 4971 and 4930 Å.

The stone contains typical inclusions (see fig. 3). There occur both needle-like and more or less hexagonal shaped dark brown forms, closely resembling the biotite flakes in peridots from Egypt. Some sixsided colourless plates are also to be seen. The same type of inclusions usually occurs in Siberian emeralds. Although we are not certain about the nature of the inclusions in question, we suppose that these are mica flakes with perhaps some hornblende.

No. 718 is a transparent yellow green trap cut stone; about one half has been broken off so that a conchoidal fracture is seen. The weight of this peridot is 0.86 carats, its size is 6.4 × 4.2 × 3.6 millimeters. The S. G. is 3.338. The pleochroism is weak in tones of yellow-green and green.

A usual refractometer reading is not possible because the table is slightly domed and the back facets are too small. With the aid of the distant vision method, however, a mean refractive index was measured at 1.67. The absorption spectrum shows some weak bands at 4972, 4936 and 4725 Å in the blue part.

There occur numerous inclusions in this stone; three crystal feathers may be seen parallel to each other and besides another one oriented in a different way. These feathers are all connected with the exterior of the stone and will certainly be healed fissures. They consist of more or less stretched negative crystals which are filled with two phases.

No. 719 is a pale yellow-green transparent stone, cut in a style which has much in common with obus. One of the corners is broken off; a conchoidal fracture may be seen there. The weight of this peridot is 0.62 carats, its size is 6.3 × 5.1 × 2.4 millimeters. Its specific gravity appeared to be 3.346.

As regards the optical properties, the pleochroism is weak, the refractive indices are $N_z' = 1.685$ and $N_x' = 1.650$. The spectroscopic inspection gave some weak bands in the blue part of the absorption spectrum at 4970, 4934, 4735 and 4526 Å.

Two crystal feathers, both in connection with the exterior of the stone, may be seen as inclusions. They are parallel to each other and consist of negative crystals filled with two phases. They show the tell-tale pattern of healed fissures and are therefore of secondary origin.

No. 720 is a trap cut transparent yellow-green stone with a large table. The weight of this peridot is 0.94 carats, the size is 6.6 × 4.7 × 3.2 millimeters. Its S. G. is 3.337. A weak pleochroism may be observed, the refractive indices are $N_z' = 1.690$ and $N_x' = 1.656$.

Absorption bands at 4970, 4934, 4732 and 4530 Å may be observed by spectroscopic examination.

There occur a number of healed fissures with negative crystals in this stone as well as a plane which contains a cloudy mass of yellowish brown material. We are not certain about the nature of this latter material but perhaps it is fayalite or limonite.

No. 729 is a worn stone, it is trap cut with a large table, pale green in colour and transparent. The weight of this peridot is 0.88 carats, its size is 6.7 × 5.0 × 2.8 millimeters. S. G. of the stone is 3.343.

The pleochroism is weak in tones of yellow-green and green, as is usual for pale coloured peridots. As the table is slightly domed, a normal refractometer reading was impossible. The mean R. I, however, observed by the distant vision method is about 1.67. The absorption spectrum shows weak bands at 4968, 4930, 4735 and 4526 Å in the blue.

Primary inclusions may be seen in this stone. There occur colourless, more or less hexagonal shaped plates in zonal orientation, from which we infer that they are mica particles. Besides these mica flakes, black dendritic forms may be seen. Of course the nature of these latter forms cannot be identified with certainty, but it is quite possible that they are built up by iron oxide.

No. 730 is a transparent pale green, trap cut, stone with a large table. Its weight is 1.06 carats, the size 7.0 × 5.4 × 3.1 millimeters. The specific gravity of this peridot is 3.340.

The optical properties are in accordance with those normal for peridot. The pleochroism is weak, the refractive indices are $N_z' = 1.689$ and $N_x' = 1.658$, measured on the table. In the absorption spectrum weak bands may be observed at 4968, 4930, 4734 and 4531 Å.

There are no diagnostic inclusions to be detected in this stone. It may be noted that some back facets are strongly worn, the grooves are filled up with foreign material, which resembles inclusions.

The other stones from Siberia (collection King William I of the Netherlands) have about the same colour and appearance as the stones described above from the same locality. But although the latter are generally cut in a trap style with a large table facet, His Majesty's stones have an oval outline and are brilliant or mixed cut. To this group of peridots belong the Nos. 703, 716, 722, 723, 724, 725, 726, 727, 728 and 731.

No. 703 is a transparent pale green stone, cut in an oval brilliant style. Its weight is 0.34 carats, the size 4.9 × 3.8 × 2.4 millimeters. The specific gravity of this peridot is rather high, being 3.362.

The pleochroism is distinct (yellow-green and green). Its refractive indices, measured on the table, are $N_z' = 1.671$ and $N_x' = 1.651$, so that the double refraction measured in this direction does not agree at all with the maximal value.

The absorption spectrum only shows some bands at 4971 and 4930 Å, more bands cannot be seen.

In the stone some liquids feathers may be observed resembling the well-known inclusions in Ceylon sapphires.

No. 716 is a trap cut transparent pale green stone with a more or less oval outline. One of the corners of this peridot has been broken off, the fracture is conchoidal. The weight is 0.39 carats, the size 5.4 × 4.0 × 2.1 millimeters. A rather high value for the specific gravity was measured (3.359).

The pleochroism is weak, the refractive indices are: $N_z' = 1.680$ and $N_x' = 1.650$. Spectroscopic investigation shows weak bands at 4968 and 4931 Å in the blue part of the absorption spectrum.

In the stone a typical healed fracture may be seen (see fig. 4). It is a succession of various conchoidal cracks.

No. 722 is a small transparent pale yellow-green stone, cut in an oval brilliant style. The weight of this peridot is 0.18 carats, the size is 3.9 × 3.3 × 2.2 millimeters. Its S. G. is rather low, being 3.311.

The stone has a weak pleochroism, $N_z' = 1.689$ and $N_x' = 1.653$ which indicates that the table is practically cut in a direction of maximal birefringence, perpendicular to N_y. In the absorption spectrum some bands may be observed at 4969, 4932, 4731 and 4530 Å in the blue.

The stone contains interesting inclusions. One may see colourless hexagonal shaped and needle-like plates of mica, zonally oriented and certainly of primary origin (see fig. 5). Besides some healed fissures are present, parallel to each other, in connection with the exterior of the stone. They contain very small and slightly larger negative crystals filled with two phases.

No. 723 is a mixed-cut square shaped stone, transparent and light green in colour. Its weight is 0.23 carats, the size is $3.7 \times 3.7 \times 2.3$ millimeters. The specific gravity of this peridot is 3.323, which is rather low.

The stone has a weak pleochroism, the refractive indices are $N_z' = 1.690$ and $N_x' = 1.655$. The typical iron spectrum may be observed by spectroscope. Some absorption bands occur at 4972, 4931, 4735 and 4534 Å in the blue.

A succession of various conchoidal cracks may be seen in the stone. It is a healed fissure of secondary origin with a tell-tale pattern.

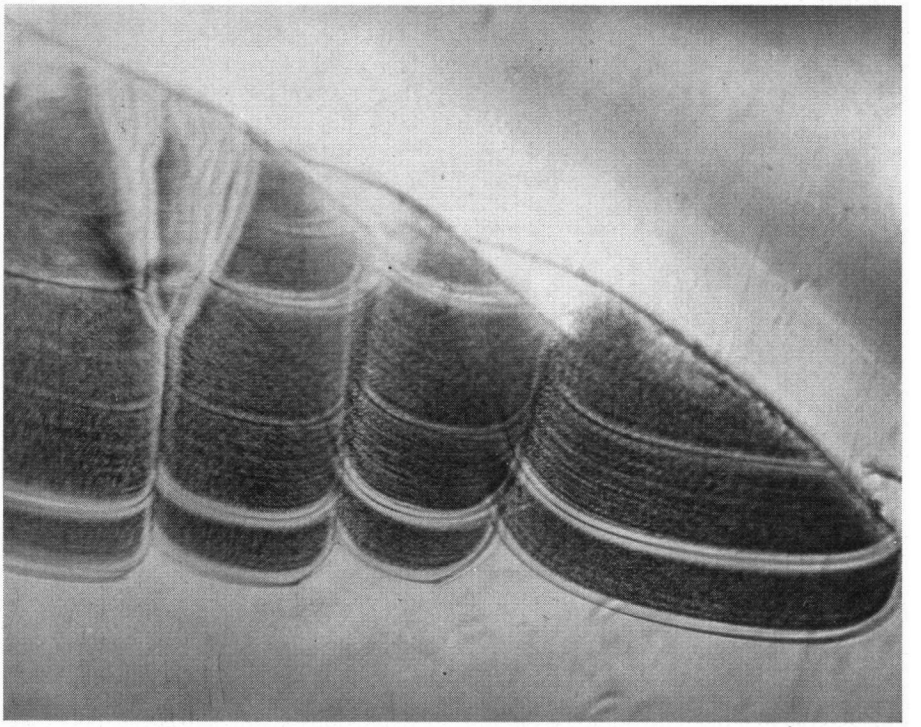

Fig. 4. Healed fracture in peridot No. 716 (× 100)

No. 724 has about the same appearance as No. 723. It is a mixed cut transparent stone with a light green colour. The weight of this peridot is 0.47 carats, its size is $4.8 \times 4.7 \times 3.1$ millimeters. The S. G. is 3.333.

As regards the optical properties, the pleochroism is weak in tones of yellow-green and green. The usual refractometer reading could not be done owing to the fact that the table facet is slightly domed and the back facets are too small. The mean refractive index was measured at 1.67. Its double refraction is high, which may be seen at the property of doubling of the back facets when viewed through the table with a lens.

The absorption spectrum shows bands at 4970, 4932, 4734 and 4528 Å.

There are no diagnostic inclusions to be described.

No. 725 is a mixed cut, transparent, light green stone with some slightly damaged facet edges. Its weight is 0.37 carats the size is 5.0 × 4.1 × 2.4 millimeters.

A rather low value for the specific gravity (3.319) was measured. This peridot has a weak pleochroism. $N_z' = 1.680$ and $N_x' = 1.660$, observed on the table.

By spectroscopic investigation some absorption bands in the blue part of the spectrum were observed at 4968, 4930, 4734 and 4531 Å.

Fig. 5. Mica inclusions in peridot No. 722, at the top of the photograph part of a healed fissure may be seen (× 100)

Both primary and secondary inclusions occur in this stone. Ony may see mica flakes in zonal orientation and besides some healed fissures in connection with the exterior of the stone.

No. 726 is a brilliant cut stone with an oval outline, the colour is light yellow-green; this transparent peridot has weakly damaged facet edges. The weight is 0.36 carats, the size 4.9 × 4.1 × 2.4 millimeters. The S. G. is 3.325.

The stone has a weak pleochroism, only a mean refractive index of about 1.67 could be measured. In the absorption spectrum only two bands are observed at 4971 and 4930 Å.

There occur a few liquid feathers in the stone, which are healed fissures.

No. 727 has about the same appearance as No. 726. It is a transparent brilliant cut stone with an oval outline, the colour is light yellow-green. Its weight is 0.39 carats, its size is 5.0 × 3.9 × 2.7 millimeters. The girdle especially is damaged. The specific gravity of this peridot is 3.330.

The pleochroism is weak in tones of yellow-green and green. $N_z' = 1.690$ and $N_x' = 1.651$, measured on the table, which indicates that the table is cut perpendicular to N_y.

Absorption bands may be seen at 4972, 4930, 4728 and 4534 Å in the blue part of the spectrum.

Primary and secondary inclusions are met with in the stone. There occur mica plates, in zonal orientation besides some healed fissures.

No. 728 is a brilliant cut transparent stone with a pillow shape, its colour is yellow-green. The weight of this peridot is 0.75 carats, its size 5.7 × 5.6 × 3.4 millimeters. The S. G. is 3.344.

A distinct pleochroism may be observed which is due to the more intensive colour of this specimen. Only a mean value for the refractive index was measured at 1.68, because the table is domed.

In the absorption spectrum bands occur at 4972, 4934, 4731 and 4530 Å.

As is the case for various stones from this locality one may see both primary and secondary inclusions in the stone in question. Mica particles in zonal orientation occur with some healed fissures which are in connection with the exterior of the stone.

No. 731 is a light yellow-green transparent stone; the style of cutting is brilliant-like with an oval outline, some facet edges are damaged. The weight of this peridot is 1.32 carats, its size is 9.8 × 5.9 × 2.8 millimeters. The S. G. is 3.340.

Its pleochroism is weak. The refractive indices, measured on the table, are: $N_z' = 1.688$ and $N_x' = 1.656$. The absorption spectrum shows bands at 4970, 4934, 4732 and 4528 Å.

Inclusions may be seen as some liquid feathers. They are healed fissures, distinctively of secondary origin.

5. *Persia?*

Although we are not certain about the origin of these peridots we shall consider the possibility they are from Persia on account of what has been said in the introduction. In the collection there are seven stones which may be from Persia. They are Nos. 706, 707, 708, 710, 711, 712 and 721. They generally have a dark tint; the table facet is often slightly domed. Usually the girdle is eightsided, the style of cutting being oldfashioned for some of them.

No. 706 is a transparent trap cut oil-green stone. Is has a drill hole lengthwise. The table is domed. The weight is 1.65 carats, the size 7.5 × 6.3 × 4.1 millimeters. The specific gravity of this peridot is 3.339.

A distinct pleochroism may be observed. The refractive index is 1.65, measured by means of the distant vision method. The spectrum shows some absorption bands at 4968 and 4931 Å in the blue.

As regards the inclusions a liquid feather may be seen, it is a healed fissure connected with the exterior of the stone.

No. 707 is a yellow-green transparent trap cut stone, its table is domed. All facts are strongly damaged. The weight of this peridot is 1.74 carats, its size is 10.0 × 6.7 × 2.7 millimeters. For the specific gravity 3.342 was measured.

The stone has a distinct pleochroism in yellow-green and green. A refractive index of about 1.66 was observed.

Spectroscopic inspection detected bands at 4972 and 4934 Å in the blue part of the spectrum.

Inclusions may be recognized with the naked eye. A few needle-like minerals are present, some of them colourless and some brownish. Their nature is not certain; it is possible, however, that they are hornblende needles or mica. Moreover a healed fissure may be observed. This feather contains negative crystals, filled with two phases.

No. 708 is a yellow-green trap cut transpararent stone. The table is very large and slightly domed. Its weight is 3.24 carats, the size is 11.5 × 8.5 × 3.5 millimeters. The specific gravity of this peridot is 3.348.

As regards the optical properties, the pleochroism is distinct in yellow-green and green. The refractive index appeared to be about 1.67, measured with the distant vision method. In the absorption spectrum bands are to be seen at 4972, 4930, 4730 and 4533 Å.

In the stone a number of healed fissures may be recognized. They are all parallel to each other and connected with the exterior of the stone. They consist of both negative crystals and more rounded forms. These feathers may be seen with the naked eye.

No. 710 is a yellow-green, transparent mixed cut stone with triangle facets instead of a table. It is strongly damaged. The weight is 8.89 carats, the size 15.0 × 11.8 × 6.2 millimeters. For the S. G. a value of 3.347 was measured.

The stone has a very distinct pleochroism, the refractive index was observed at about 1.67, more or less corresponding with Ny.

Absorption bands occur at 4970, 4935, 4731 and 4529 Å in the blue part of the spectrum.

There are no inclusions to be described, but there are some sling-shaped cracks filled with air. Quite possibly these cracks are due to the fact that the stone was dropped at one time.

No. 711 is a transparent stone one half of which has been broken off, therefore a conchoidal surface of fracture may be seen. It is trap cut with a large, slightly domed, table. The colour is yellow-green, its weight is 6.63 carats, the size is 12.7 × 8.1 × 7.0 millimeters. Its S. G. is 3.345.

The pleochroism is distinct in tones of yellow-green and green. A refractive index was observed at about 1.67.

By spectroscopic investigation some bands were seen at 4971, 4934, 4734 and 4526 Å in the blue part of the absorption spectrum.

Only an internal crack, filled with air, occurs as an inclusion.

No. 712 is a yellow-green transparent trap cut stone, its facet edges are strongly damaged. The weight of this peridot is 6.73 carats, the size is 13.8 × 11.0 × 5.1 millimeters. The specific gravity is 3.345.

The stone has a distinct pleochroism, the refractive indices, measured on the table are $N_z' = 1.685$ and $N_x' = 1.650$.

Absorption bands occur at 4970, 4935, 4726 and 4530 Å.

With the naked eye inclusions are to be seen. They are feathers with the tell-tale pattern of a healed fissure consisting of negative crystals and more or less irregular forms. These feathers are oriented in several directions.

No. 721 has a pale yellow-green colour, it is a transparent stone, cut in a trap-like style with a slightly domed table. At some places the stone is strongly damaged, there conchoidal fractures may be seen. The weight of this peridot is 1.08 carats, its size is $7.4 \times 5.9 \times 2.9$ millimeters. For the specific gravity a value of 3.344 has been measured.

Only a weak pleochroism is seen, a refractive index near 1.67 was observed. The absorption spectrum shows bands at 4972, 4930, 4735 and 4532 Å.

A feather with very small and also somewhat larger negative crystals occurs as an inclusion.

Discussion of the results.

On comparing the aforesaid data on peridots from various localities one will notice a few interesting aspects. First of all one should bear in mind that what has been said on the origin of these stones in the introduction also holds good for the conclusions. Otherwise one might get inaccurate results.

For clearness' sake the properties will be treated one by one.

a. *Colour.*

All the stones have a more or less intensive typical yellow-green to oil-green colour. No characteristic colour can be attributed to stones from a particular locality although the peridots from Siberia and Brazil are pale when compared to those from other localities. But we should not attach too much importance to this, as the stones in question happen to be the smallest in the whole collection.

b. *Pleochroism.*

All the peridots show a distinct to weak pleochroism in tones of yellow-green and green. The degree of this property depends on the intensity of the colour of the stone. So no variations in pleochroism are to be found depending on the locality.

c. *Absorption spectrum.*

In general all the peridots here described show the typical spectrum due to iron. Bands occur in the blue part at 4970, 4930, 4730 and 4530 Å with only small deviations. The strength of these bands often depends on the vibration direction of the transmitted light. This phenomenon is not unusual for anisotropic stones. Some Siberian and Persian stones do not show the bands at 4730 and 4530 Å; they are all rather small and somewhat pale in colour.

The largest peridot of the collection has a vague band at 6342 Å, which is due to chromium. Quite possibly other peridots also show chromium bands, only they may be too weak to be noticed with the normal methods. It is clear therefore that the absorption spectrum cannot give any clue as to the origin of peridots.

d. *Refractive indices.*

As regards this optical property all the peridots appear to have practically the same values for the lowest and the highest refractive indices, for the readings on the refractometer vary from 1.650 as the lowest value to 1.690 as the highest value, irrespective of locality. All the readings with the distant vision method are in between the values given above.

The double refraction is rather strong for all the stones; this appears either from readings on the refractometer or from the fact that one may see doubling of the back facets when viewing through the table with a pocket lens. Measured on the table one of the stones (No. 727) has a double refraction of 0.039, which is generally considered to be the maximal birefringence for peridots. But the average value of the double refraction is 0.029, as appears from data on the refractive indices measured on the refractometer.

Before concluding from these data what will be the approximate chemical composition of these peridots we shall first examine the results of the specific gravity, especially as we do not have any other optical data as for instance the optic axial angle.

e. *Specific gravity.*

The specific gravity of the peridots described varies from 3.311 as lowest to 3.362 as highest value. Attention should be drawn to the fact that the method used for determining these values is inaccurate for small stones. If only stones weighing more than 1.00 carat are taken into account, the variation is already found to be much smaller, namely 3.327 to 3.348.

The peridots from Pegu, which are all rather big stones, vary in their S. G. from 3.346 to 3.348, those from Persia (weighing over 1.00 carat) from 3.339 to 3.348. So it is evident that the accuracy of the hydrostatic weighing method increases with the weight of the stone. But from these data it also becomes clear that the specific gravity of peridots cannot give any reliable clue as to their origin.

The combined optical and physical data (refractive index, double refraction and specific gravity) can be indicative of the chemical composition of the peridots without the aid of the chemical analyses. We plotted our data in diagrams of POLDERVAART (1950), WINCHELL (1951) and TRÖGER (1956) on the isomorphous series forsterite-fayalite. Owing to the narrow range of these properties the three diagrams show our peridots to have a position at about 11 mol. % $Fe_2 Si O_4$. in this series. The variation is from 8 to 14 mol. %. It seems remarkable that all the peridots described in this paper, though from several localities have about the same chemical composition.

f. *Inclusions.*

It is seen, that both primary and secondary inclusions occur in peridots.

The primary inclusions are often oriented to a crystallographic direction and are found in zonal orientation.

The secondary inclusions are healed fissures, in connection with the exterior of the stone.

As regards their nature the primary inclusions are mica flakes, droplike forms and perhaps hornblende.

The healed fissures consist of either negative crystals filled two phases or liquids. They often show a tell-tale pattern of large inclusions surrounded

by a collar of smaller inclusions in the thinner part where the remedial action began.

The stones from Egypt contain biotite flakes, which seems typical for peridots from this locality. We noticed, however, that one of the stones from Siberia (No. 717) also contains such inclusions, although in combination with a few colourless mica plates and perhaps some hornblende. So after all the presence of only biotite in a peridot might be an indication of its locality.

Only one of the four Brazilian stones described here contains inclusions. Therefore we cannot conclude anything from this.

Two of the stones from Pegu contain secondary inclusions. They are healed fissures, which may occur in the same way in stones from Siberia and Persia; so they cannot be looked upon as diagnostic for peridots from this locality.

It appears that Siberian stones may contain mineral, two phase, and liquid inclusions. The minerals included are usually colourless mica plates, only in a few cases they are brown mica particles and perhaps hornblende. The feathers contain negative crystals or more rounded forms filled with two phases besides liquid inclusions. A combination of colourless mica with a healed fissure seems typical for peridot from Siberia.

Finally the Persian stones appear to contain liquid and two phase inclusions only. From what is said above it is clear that it cannot be looked upon as diagnostic for this locality.

Summarizing the following may be noted: Peridots of gem quality from all localities here described have more or less the same chemical composition. This implies that it is impossible to determine the origin of peridots from physical data (especially optical data). Diagnostic inclusions are only found in peridots from Egypt and Siberia.

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