NOTES ON THE OCCURRENCE OF PIEZOELECTRIC QUARTZ IN AUSTRALIA
WITH SPECIAL REFERENCE TO THE KINGSGATE FIELD.

BY

M. D. GARRETTY, M.Sc.
CONSULTING MINING GEOLOGIST.

Issued under the authority of the Hon. W. P. Ashley,
Minister for Supply and Shipping.

By Authority:
(Printed in Australia.)
1949
List of Reports of the Bureau of Mineral Resources, Geology and Geophysics, already issued and to be issued either in printed or duplicated form.


Bulletin No. 2—(Palaeontological Series No. 2)—"The Larger Foraminifera of the Lower Miocene of Victoria". By I. Crespin. Printed and issued 1936 as Palaeontological Bulletin No. 2.

Bulletin No. 3—(Palaeontological Series No. 3)—"The Occurrence of Locasiina and Biplanispira in the Mandated Territory of New Guinea", and "A Lower Miocene Limestone from the Ok Ti River, Papua". By I. Crespin. Printed and issued August, 1938, as Palaeontological Bulletin No. 3.


Bulletin No. 6—(Miscellaneous Series No. 2)—"Fluorescence of Scheelite and Its Application to the Mining Industry". By J. M. Rayner. Roneoed and issued 18th September, 1942, as Miscellaneous Report No. 2.

Bulletin No. 7—(Miscellaneous Series No. 3)—"Preliminary Study of Australian Diatomites with Special Reference to Their Possible Value as Filter Media". By I. Crespin. Roneoed and issued 5th January, 1943, as Miscellaneous Report No. 3. Printed and issued January, 1948.


Bulletin No. 11—(Geological Series No. 2)—"The King Island Scheelite Mine". By P. B. Nye and C. L. Knight. Roneoed and issued December, 1943.


Bulletin No. 15—(Palaeontological Series No. 5)—"Foraminifera in the Permian Rocks of Australia". By I. Crespin. Printed and issued September, 1947.

* In course of publication.
† Only limited distribution made; to be printed later.
NOTES ON THE OCCURRENCE OF PIEZO-ELECTRIC QUARTZ IN AUSTRALIA WITH SPECIAL REFERENCE TO THE KINGSGATE FIELD.

BY

M. D. GARRETTY, M.Sc.
CONSULTING MINING GEOLOGIST.

Issued under the authority of the Hon. W. P. Ashley.
Minister for Supply and Shipping.

By Authority:
(Printed in Australia.)
1949
TABLE OF CONTENTS.

Foreword .............. 4
1. Introduction .......... 5
2. Preliminary Selection of Prospects for Examination ....... 6
3. Criteria used in Judging Prospects in the Field .......... 7
4. Summary of Conclusions .......... 8
5. Principal Australian Localities ........ 8
   A. Queensland ......... 8
     (i) Duck Creek ........ 8
     (ii) Croydon .......... 8
     (iii) Petford ......... 8
     (iv) Stanthorpe ...... 8
     v) Wonbah Knob ...... 8
     vi) Morinish .......... 9
     (vii) Palmer River District .......... 9
     (viii) Wolfram Camp Field .......... 9
   B. New South Wales ......... 9
     (i) New England ...... 9
     1. The Kingsgate Field ......... 9
        (a) Introduction ......... 9
        (b) Distribution of Pipes ......... 10
        (c) Shape and Attitude of the Pipes ......... 11
        (d) Persistence of Pipes in Depth ......... 12
        (e) Occurrence of Crystal in Pipes ......... 13
     2. Country South of Kingsgate ......... 14
     3. Other Localities ......... 15
        (ii) Broken Hill ......... 15
        (iii) Tarana .......... 15
   C. Victoria ......... 15
     (i) Bendigo .......... 15
     (ii) Kingower ......... 15
     (iii) Tallangalook ......... 16
     (iv) Other Localities ......... 16
   D. Tasmania ......... 16
     (i) Gladstone-Mount Cameron ......... 16
   E. South Australia ......... 17
     (i) King’s Bluff ......... 17
     (ii) Kirkeek’s Treasure Gold Mine ......... 18
     (iii) Wadnaminga Goldfield ......... 18
     (iv) Teetulpa Goldfield ......... 18
     (v) The Prince Albert Copper Mine ......... 18
     (vi) Mount Lofty Quarries ......... 18
   F. Western Australia ......... 19
     (i) Goomalling ......... 19
     (ii) Morowa ......... 19
     (iii) Payne's Find ......... 20
     (iv) Kalgoorlie District ......... 20
6. References ......... 20
Appendix.—Schedule of Pipes, Kingsgate ......... 21

LIST OF PLATES.
Plate 1.—Map showing principal localities for Piezo-electric Quartz in Australia.
Plate 2.—Geological Plan and Sections of Kingsgate Quartz Crystal Field.
Plate 3.—Sketch Geological Plan of the District South of Kingsgate.
FOREWORD.

For a time during the war it appeared that there would be an acute shortage of piezo-electric quartz in Australia. Accordingly it was necessary to investigate all known deposits and reported occurrences of quartz, with a view to seeing whether further or new development was possible. This work was the responsibility of the Controller of Minerals Production, Mr. J. Malcolm Newman, who placed the investigation in the hands of North Broken Hill Limited. This company arranged for its Consulting Geologist, Mr. M. D. Garrett, to make the necessary field investigations and draw up a programme of development. Mr. Garrett thus had a unique opportunity to look into reports on occurrences of piezo-electric quartz in Australia and to examine all those deposits which showed any promise. The results of his investigation are summarized in this Bulletin, which was prepared in August, 1944, although minor revisions have been made up to December, 1946.

A considerable part of the bulletin deals with the Kingsgate area, New South Wales, from which noteworthy quantities of quartz crystals have been obtained and which is still considered to be the most promising area for crystal in Australia. Mr. Garrett’s conclusions about this field should prove of general interest and the presentation of his results will provide a basis for future prospecting.

It is desired to thank Mr. Newman for releasing the results of this investigation and to express appreciation to North Broken Hill Limited for their co-operation, and to Mr. Garrett for writing up his results in their present form.

A previous bulletin issued by this Bureau—No. 10, by F. Canavan—contained a general discussion of piezo-electric quartz and may be read as an introduction to Mr. Garrett’s description of its occurrence in Australia.

H. G. RAGGATT, Director,
Bureau of Mineral Resources, Geology and Geophysics.
NOTES ON THE OCCURRENCE OF PIEZO-ELECTRIC QUARTZ IN AUSTRALIA, WITH SPECIAL REFERENCE TO THE KINGSGATE FIELD.

1. INTRODUCTION.

The shortage of high-grade piezo-electric quartz was felt early in the war, and efforts were made, principally by Amalgamated Wireless (A/asia) Ltd., and Radio Corporation Pty. Ltd., to investigate reported occurrences of quartz crystal at places other than the main producing field at Kingsgate, New South Wales. The co-operation of North Broken Hill Limited in crystal mining had been obtained by the Controller of Minerals Production (Mr. J. Malcolm Newman) in 1943 and attention was given in July of that year to co-ordination of the prospecting work being carried out. The writer, as Consulting Geologist to North Broken Hill Limited, was placed in charge of the work.

A good deal of information and correspondence was available in the files of Amalgamated Wireless (A/asia) Limited, and the Government Geological Surveys. Reports on some individual fields had also been made by Survey officers, including several from the Bureau of Mineral Resources (Canberra).

Preliminary investigation showed that—

(i) A very large number of localities, in all States, had been brought to notice as possible producers of suitable crystal.

(ii) Some of the occurrences were referred to in Geological Survey publications, but most were not.

(iii) Authority for the reported occurrences varied from the casual letters of farmers to specific reports by geologists or mining engineers.

(iv) The few technical reports specifically dealing with quartz crystal showed a lack of confidence in the judgments given, probably due to the absence of a suitable yardstick with which to value the deposits. Deposits of quartz crystal cannot be sampled and assayed as can those of most other minerals.

It was considered essential, therefore, that all the prospects thought to have a reasonable chance should be examined by one individual. A uniform (though perhaps arbitrary) standard of value would thus be applied. Following a report along these lines, the investigation was placed in the hands of North Broken Hill Limited by the Controller of Minerals Production and the field work carried out by the writer.

The field examinations necessarily involved an appraisal of the quality of crystal specimens. However, the factors governing the usability of quartz crystals have been described by Canavan (1943) in a bulletin issued by this Bureau, and will not be further dealt with here.

2. PRELIMINARY SELECTION OF PROSPECTS FOR EXAMINATION.

From the large number of localities, a selection was made for field examination.

Any locality known to have produced crystal actually used for piezo-electric purposes was placed high on the list. Localities from which samples of crystal approaching usability in size and quality had
been received were also marked for attention. The publications of all the State Surveys had been combed in detail by a research officer of Amalgamated Wireless (Asia) Limited, and the results were available; references suggesting the likely occurrence of usable crystal were noted. Quartz crystal has rarely received direct mention in Australian Geological Survey publications, undoubtedly because of its lack of importance in the past.

From the list of localities thus compiled were eliminated those which, from personal knowledge, from a study of the literature, or from information supplied personally by geologists or engineers, were known to be unworthy of special examination.

In most instances the quartz crystal prospects are abandoned mines. They had been worked for other minerals and the quartz obtained as a by-product.

Plate 1 shows the chief localities in which quartz crystal of appreciable size is found.

3. CRITERIA USED IN JUDGING PROSPECTS IN THE FIELD.

In assessing the value of any quartz crystal prospect, the following points are important:

(i) Does crystal of usable quality occur? In most instances, the field examination, commonly supported by inspection of the mine's "best specimens" as seen in local collections, was sufficient to show that the crystal either did not attain the size, or was not of sufficiently good quality to be of use. However, if crystals of sufficient size and apparent clarity were found, samples were despatched to the laboratories of Amalgamated Wireless (Asia) Limited for further testing.

(ii) If usable crystal does occur, how plentiful is it? What are the chances of securing a supply from the old spoil dumps? If obtaining more crystal would necessitate reopening old workings and commencing mining operations, how does the expected return of crystal per unit of work compare with that in other localities? Considerations of this kind rule out such fields as Bendigo and Croydon, even though usable crystal may have been produced in the past.

(iii) What are the conditions under which the quartz crystal occurs in the deposit? Does it occur in vughs or pockets irregularly distributed throughout the lodes, as at Kinggate, offering excellent chances for a continuance of the supply? Or does it occur as the lining of a fault in the ore body, or perhaps (as a rarity) in points of structural anomaly, as at Bendigo? These latter offer little encouragement for getting further supplies from a reasonable amount of mining work.

(iv) Is a continuation of mining likely to produce amounts of crystal comparable with those found in the past? An extreme case is the Teetulpa (South Australian) field, where superficially enriched gold-quartz reefs have been worked to water level. A few good loose crystals were
found in the old dumps, but further exploitation would necessitate mining below water level, where the crystals, if present, would be encased in a solid matrix of siderite. The siderite has been weathered away from the crystals found near the surface.

Fundamentally, the appraisal of a quartz crystal deposit is similar to that of any other lode. Outstanding differences, however, are to be found in the data available. The quartz crystal deposit may be likened to the bonanza type of gold or silver deposit, in which (small) rich patches occur separated by (extensive) zones of unpayable ground. It is to be contrasted with the normal Australian gold or base metal deposit in which grade variations occur, but in which payable ore is continuous in shoots which may provide many years' life. The geologist is called upon to estimate the probable value and frequency of the shoots and vughs in the quartz crystal deposit at the outset. In the metalliferous mine he is usually asked to find new ore shoots only after a good deal of information is available about those already mined, and is in a better position to deduce and apply any structural or other ore control which may exist.

Again, it is universally admitted to be a serious handicap in mine valuation if there is not free access to assay plans of records of past production. In the quartz crystal investigation, it was extremely difficult to get information concerning production. Moreover, in the quartz crystal deposit it is not usually possible to re-sample, as could be done in a metalliferous mine.

4. SUMMARY OF CONCLUSIONS.

Most of the prospects visited were regarded as having little or no chance of becoming producers of quartz crystal. At many localities, it could not be established that usable crystal occurred, while in others good crystal had been obtained in the past, but in infinitesimal quantity compared with the amount of mining done.

The remainder were classified as either good fields warranting immediate full-scale production, or less important fields which should be developed, but whose ultimate output was uncertain. The first group consisted of Kingsgate (New South Wales) and Gladstone (Tasmania). The second group comprised Wolfram Camp in Queensland; Comstock, Pretty Valley and Mount Gibraltar (near Kingsgate), Sandy Hill, Crystal Palace and Tarana, all in New South Wales; Inglewood in Victoria; King's Bluff in South Australia; Goomalling in Western Australia. After testing, Sandy Hill, Crystal Palace, Tarana and Inglewood were found wanting. Wolfram Camp, King's Bluff and Goomalling have not yet been tested. The remainder have produced some crystal, but their value is still uncertain.

Throughout the inquiry it was assumed, on the basis of information available, that an increase in production was a vital necessity, and that economic considerations were of secondary importance—to be considered only in assessing the relative merits of various fields.

The present classification of deposits is as follows:

The Kingsgate district is outstanding. The potential supply of crystal is large. Next on the list is Gladstone, which should produce well while the dumps last. However, the ultimate production is strictly limited. The Comstock-Pretty Valley and Mount Gibraltar deposits
have produced a little crystal lately, but have not been proved substantial sources of supply. The Goomalling, Wolfram Camp and King's Bluff districts may become subsidiary producers if developed, but the potentialities are at present unknown.

It may be remarked here that the number of localities in which has been found crystal which is big enough, but not clear, or which is clear enough, but too small, is legion. If a deposit has been reasonably well opened up, the presence of such crystal offers, in itself, little hope that usable specimens will be found by a comparable amount of mining work.

5. PRINCIPAL AUSTRALIAN LOCALITIES.
(See Plate 1 for position of localities described.)

A. QUEENSLAND.

References in the publications of the Queensland Geological Survey led to a number of localities being investigated. These included the Cloncurry-Duck Creek, Croydon, Petford and Stanthorpe districts.

The Wolfram Camp field had come under notice because of crystal samples which had been sent in for examination. Wonbah Knob was recommended for investigation by the Queensland Geological Survey.

(i) Duck Creek.—Occasional interlocking crystals “up to three inches across” have been produced from Duck Creek, 29 miles south-south-west of Cloncurry. However, most of the crystals from this locality are much smaller—about a quarter of an inch in cross-section.

(ii) Croydon.—In the Queensland Mineral Index (Dunstan 1913), it is stated that large crystals, up to 8 inches in diameter, occurred in the Croydon mines (85 miles east-south-east of Normanton). The best crystal find is believed to have been in the Content Mine. The mines are inaccessible, but the dumps of a number of them were carefully examined, particularly that of Content Mine. The only crystals seen were interlocked aggregates, the individuals not exceeding half an inch in length. Doubly terminated crystals up to four inches in length were examined in private homes, but none was clear enough for use. The larger ones referred to in the old report were probably rare. It is said that quartz crystal from Croydon has been used in radio sets for the Australian Inland Mission, but the number of oscillators made and the tolerances allowed are unknown. The chances of finding suitable crystal, by working over the dumps or rehabilitating the very extensive workings, are so remote that neither operation would be warranted.

(iii) Petford.—Specimens obtained from a dump 8 miles north of Petford (62 miles west-south-west of Cairns) are large fragments of big crystals, but only a few have any fairly clear portions. The prospect of obtaining better crystal is not encouraging.

(iv) Stanthorpe.—At this locality the tin-bearing wash contains only a small proportion of pebbles, and quartz crystals are uncommon. None of them is large enough to be of use.

(v) Wonbah Knob (46 miles west-south-west of Bundaberg).—Crystals up to 8 inches long and 5 inches wide occur near Mount Perry. The large ones are intergrown. Only a few very small crystals (1 inch by ½ inch) are clear; larger ones are dense milky white.
(vi) Morinish (25 miles north-west of Rockhampton).—Specimens from this and other localities were examined, but proved unsuitable.

(vii) Palmer River District.—Two specimens from Palmer River (36 miles south of Laura) were encouraging in that one was an inch and a half in diameter, and originally clear; the flaws present are apparently due to fracturing in the stream bed. Both specimens were strongly twinned. Further details regarding this locality are not available.

(viii) Wolfram Camp Field (58 miles west of Cairns).—The only mine at Wolfram Camp of any importance for crystal production is the Enterprise. About 2 tons of quartz had been sent away from the dump of this mine (November, 1943), but the crystal actually accepted and paid for had amounted to only 24 lb. (value £72). The total amount of crystal likely to be present in the dump is small and an ultimate production more than a few times greater than that already obtained cannot be expected.

The mine workings were not accessible, but it is said that the vugh has neither been followed to its limits nor been denuded of all its crystals in the exposed portion. The vugh occurs in a pipe of the Kingsgate type and at a depth of nearly 300 feet. The average cross-section of the pipe is about 12 by 12 feet, but the vugh walls widen to about 20 by 20 feet. The vugh is in a sub-horizontal branch of the pipe, and is said to continue strongly at the face, about 80 feet from the main pipe.

Production of crystal from the mine itself would probably be confined to remnants in the developed part of the vugh, plus the full extraction from any undeveloped section. Once this vugh were worked out, it is most unlikely that another would be found without a great deal of development work, as this is said to be the only large one known on the field to date. A vugh found in the Harp of Erin mine many years ago is understood to have contained only a few large cloudy crystals.

B. NEW SOUTH WALES.

(i) New England.—This district is the most important in New South Wales, and indeed in Australia, for quartz crystal. Crystal of usable, or nearly usable, quality and size has been in many places north from Guyra to the Queensland border. The usual form of occurrence is in vughs or as loosely packed crystal aggregates in tin-molybdenite- or bismuth-bearing "pipes". These pipes have been adequately described in publications of the New South Wales Geological Survey (Andrews, 1906, 1916. Carne, 1912).

1. THE KINGSGATE FIELD. (See Plate 2 and Appendix.)

(a) Introduction.—The pipes of the Kingsgate district (16 miles east of Glen Innes), have eclipsed all others in degree of productivity and, in fact, are the only ones on which work has been sustained to the date of writing this Bulletin. Most of the production of crystal from this field has come from the waste dumps formed when the pipes were being actively worked for bismuth and molybdenite. The gradual easing of specifications for crystal, consequent on the acute shortage of supply, coupled with technical improvements in processing, has led to some of the dumps being turned over several times.
The rich yield of easily obtained quartz crystal from the dumps eventually fell off, and attention was given to opening up the pipes and gaining more crystal by mining new ground, or stripping the walls of the already worked portions of pipes. Naturally, the returns were poor for the expenditure incurred, compared with the already mined dump material, and the impression grew that the pipes had been virtually worked out so far as crystal was concerned. It has not been sufficiently appreciated that the crystal won from dumps at the “Mount Morgan” (No. 34, Plate 2) section of the field has been brought to the surface during the mining of about 40,000 tons of pipe material, and that this is equivalent to about 5,000 feet of extraction on a pipe 10 feet by 10 feet in cross-section.

A survey of the Kingsgate field and the country to the south showed that the pipes were not distributed at random, but bore a close relation to the morphology of the contact surface between the granite (in which they occur) and the invaded sediment.

Careful classification of each Kingsgate pipe on the basis of its past production of crystal is subject to the following severe limitations:

(i) For most of the pipes the only information available on past production is that which can be gleaned from an examination of the dumps. The personal recollections of old identities on the field were not in accordance with this visual evidence and were, in general, unreliable as to both the amount of mining carried out in any pipe and the type of quartz found.

(ii) The accessible portions of the largest dumps do not give a satisfactory sample of the total material mined.

(iii) It is not possible, for most pipes, to correlate crystal found on the dump with any particular section or branch of the pipe.

(iv) If it should happen that each pipe in any given area possessed a similar chance of producing some usable crystal during the extraction of, say, 200 feet of pipe, there would still probably be a discrepancy in the proportion of crystal showing on the various dumps. Thus a pipe which had been worked for only 40 feet could easily show no crystal at all. A pipe worked for 150 feet might have a dump showing much crystal even though the interval between crystal vughs exceeded 40 feet.

(v) It is undoubtedly true that much of the crystal produced from pipes in the past has been crushed with other ore, and is thus not seen on the dump to-day. No satisfactory allowance can be made for this source of error.

(b) Distribution of Pipes.—In the past there has been no genuine grouping of the Kingsgate pipes into productive and non-productive zones. Commonly, pipes whose dumps have supplied much crystal have been neglected while others offering little encouragement have been developed. It follows that to conduct the mining in a way which will produce most crystal, the pipes must be classified as good or bad on the factual evidence of dumps and accessible workings, notwithstanding the five difficulties enumerated above.
Using the field evidence, the two zones on Plate 2 have been outlined. Most of the pipes in these zones show crystals of sufficient size for use. To expect to see crystals of usable quality on the exposed surfaces of the dumps would be unreasonable, if for no other reason than that even good producing pipes have a very small ratio of usable to useless quartz in crystals of sufficient size. Of the pipes in the two zones, those which did not show encouraging crystal on the dumps have been worked almost without exception only to very shallow depths.

Of the pipes outside the two zones shown on Plate 2, many show no signs of crystal, some show poor evidence of the presence of crystals of quartz, but only two can possibly be named as prospects to be classed with the average of those in Zones I. and II. They are—

(i) Quinn’s Find (No. 1 on Plate 2), Por. 24, Ph. Kingsgate, Co. Gough. Signs of large smoky crystals and also some very small clear crystals.

(ii) Little Tunnel, or Old 26 (No. 10 on Plate 2). White and glassy quartz; some crystals up to 3 inches long.

Field mapping included the compilation of contours and more accurate definition of the granite-sediment contact than was previously available. The data were used in constructing the longitudinal and two transverse sections of the field shown in Plate 2. The longitudinal section shows the contour of the land surfaces along the section line A–B, with projections of adjacent pipes; the latter are shown as steeply inclined in most instances, due to foreshortening. The granite-sediment contact has been reconstructed where necessary by projecting down the dip to the section plane.

The outstanding feature of the longitudinal section A–B is the way in which the favorable zones I and II of Plate 2 are seen to be related to an apparent doming of the contact surface. This affords an independent and convincing confirmation of the reality of the two zones as shown in plan.

The evidence of the field as a whole is not favorable to the view that mere proximity to the granite-sediment contact is particularly favorable for the occurrence of either crystal or metallic minerals. The idea probably arose because of the phenomenal value of Sachs’ pipe in the early days, this pipe being very close to the contact. Consideration of the pipes of the field shows that while all of them are within about 500 feet of the contact (measured perpendicularly therefrom), the production of crystal or metal has been controlled by the zones already discussed and not by distance from the contact.

(c) Shape and Attitude of the Pipes.—It has long been recognized that the pipes may branch upwards or downwards from any point. Individual branches also commonly have tortuous and angular courses.

It was at first thought by Andrews (1906, p. 14), that the course of a pipe and its branches was determined by the intersection lines of joint planes in the granite. He appears to have abandoned this view at a later stage (1916, p. 28). Certainly there is little actual evidence of such a control visible in the field. Nevertheless, it is axiomatic that the paths taken by the pipes must, in some way, have been inherently more penetrable by the solutions than the surrounding
granite. The elucidation of the cause would probably aid in any search for new pipes, and would also contribute to an understanding of the distribution of quartz or other mineral from pipe to pipe, or in any one pipe. However, it would serve no useful purpose at present. There is no shortage of pipes. Barren sections of pipe must be mined to provide access to the crystal-bearing sections.

The pipes occur in all azimuths and with all dips. Cross-sections drawn through the field at right angles to the granite-sediment contact have usually shown the pipes to be dipping more or less perpendicularly into the ground and hence more or less perpendicularly to the granite-sediment contact surface.

This does not represent the true facts, the two following factors being operative to falsify the picture:

(i) Any pipes not lying in the vertical plane of the cross-section are usually projected onto it, thus steepening their apparent attitude.

(ii) Assuming that the length of each pipe is limited and that the position and attitude of each pipe is random, any land surface is likely to disclose an unduly high proportion of pipes steeply inclined to it. (In other words, pipes of a given length dipping steeply are likely to outcrop over a much greater erosion span than are pipes dipping flatly. In point of fact, several of the most important pipes of the field—"Mount Morgan", Old 25, and Sachs' Pipe, for example—dip sub-parallel to the contact surface.)

(d) Persistence of Pipes in Depth.—There is apparently no authentic instance of a pipe having completely died out in depth. It is true that Goodwin's Pipe and others are said to have been bottomed during recent activity on the field. However, experience in the past has shown, as on Sachs' Pipe which was for some years regarded as mined out, that a narrow extension of the pipe may lead to wider portions again in depth. Several of those recently said to have "cut out" were found on examination not to have done so. In any event, it is inconceivable that the small amount of recent mining should have reached bottom in a number of pipes when the extensive mining of the past did not find the end of one.

On the other hand, it is clear from the accepted mode of origin of such pipes that there must be a limiting distance from the sedimentary roof below which pipes will not occur. This will correspond to the thickness of the original "chilled margin" of the granite at the time of expulsion of the hydrothermal solutions from the magma. To attempt to estimate this distance in plan is futile because of the variations in topography. However, the cross-sections studied in conjunction with the plan (Plate 2) give concrete information. They show that no pipes occur in granite which is more than 500 feet perpendicularly from the sedimentary cover. That this is not due mainly to mining costs having prevented the pipes being worked to greater depths is well shown on Section C-D (Plate 2), where there is ample opportunity for fairly shallow workings to occur at distances greater than 500 feet from the contact.
The limit of depth thus suggested will have no serious effect on pipe mining at Kingsgate in the near future. Many of the pipes, inclined at a low angle to the contact surface, could extend for great distances without passing through the outer 500 feet shell of granite.

(e) Occurrence of Crystal in Pipes.—The quartz crystal occurs in two main forms in the pipes—as free crystals in vughs, and as crystals embedded in a friable matrix of kaolin. The two forms are illustrated by the Old 25 and Arsenic pipes on the one hand, and the Giant's Blow Pipe on the other. (No. 14, 28 and H respectively on Plate 2). Crystals of the first type appear to have grown in "open spaces" (containing no solids). These spaces apparently were produced because the hydrothermal waters locally removed rock in solution at a faster rate than quartz was deposited. Crystals of the second type "grew" in the granite from isolated nuclei by replacing the rock; the crystals grew by the simultaneous solution of the granite lying in their path—specimens illustrating this point were found at Mount Gibraltar, north of Kingsgate. It is only by virtue of the wholesale conversion of the felspar of the granite to an aggregate of fine kaolin and mica that the huge doubly terminated crystals can be extracted easily to-day; they would be practically inextricable if embedded in fresh granite.

Although in the early days at Kingsgate certain empirical guides had come to be established concerning the distribution of the metallic minerals in the pipes, these did not apply rigidly. Thus, although it was well known that the rich concentrations of bismuth usually occurred along the "gutter" or footwall of a pipe, the metal was also found in other situations. No tradition was established regarding the occurrence of quartz crystals, although it now appears that vughs are apt to be found in sections of pipe not carrying appreciable molybdenite or bismuth, and even in protuberances from the pipe into the granite walls. Since very little actual mining (as distinct from stripping) has been done in recent times, it is not possible to say whether or not the vughs were as common in the metalliferous sections which were selectively extracted in the early days as they are in the portions of the pipes now being mined. It follows that, at least pending further observation, the development of new sections of pipe must be done in such a way as to test fully the complete cross-sectional area.

It is possible, though data are not good enough to demonstrate the point, that the distribution of crystals along the length of a pipe is quite erratic and that productive sections will alternate with stretches of pipe yielding no usable quartz. This would be in line with the distribution of metalliferous ore shoots in similar lodes the world over, and is moreover in harmony with the known behaviour of the metalliferous constituents of the Kingsgate pipes themselves. Nevertheless, it is a point which is not sufficiently appreciated by the main operators on the field, since there is a marked tendency to regard a pipe as exhausted as soon as the actual production of crystal falls away. Any scheme designed to secure the maximum production of crystal in a short time must fully allow for this by having a high ratio of development to crystal extraction. In normal times, the cost of this developmental work would largely determine the success or failure of the crystal mining venture.

The large amount of mining done in the past to produce the crystal-bearing dumps at "Mount Morgan" has been mentioned above. While it is true that some of the crystal extracted from the other pipes
may have been destroyed by milling for metal extraction, it is also true that this appears to be the best section of the whole field for crystal. These statements are not intended to reflect on the importance of Kingsgate as a crystal producer. There is no information which suggests that the ratio of usable crystal to surrounding rock is any more favorable on any other field in the world, although nature may have helped to lower the extraction costs, as in Brazil and at Gladstone in Tasmania.

2. Country South of Kingsgate.

Mapping of the granite-sediments relationship was extended over a belt fifteen miles long, south of Kingsgate, to determine whether any of the localities within it were likely to become good crystal producers. The mapping is summarized in Plate 3. Other than the Kingsgate field itself, the chief localities are Comstock, Pretty Valley and the alluvials of the Mitchell River. This geological and topographic mapping was done on a scale of 500 feet to one inch, chiefly by L. W. Parkin, B.Sc.

The granitic-sedimentary rock contact is essentially the eastern margin of a granitic region, with pendants or projections of sediment extending into the granite. The arches of granite and the keels of the roof pendants appear to have a general south-easterly pitch. However, the isolated "islands" of sediments, as at Pretty Valley, suggest that the pitch is undulatory, since topographic relief will not completely explain their occurrence. The inflections of the contact surface at Kingsgate, associated with the two zones of productive pipes, are probably also manifestations of pitch change.

Several independent lines of reasoning may be pursued in the interpretation of the mapping.

Following the generalizations reached from a study of the Kingsgate field proper—namely, that the productive pipes are determined by domes or terrace-like modifications of a pitching batholithic roof—the mapping has shown a lack of promise in the region to the south. Minor dome-like ornamentation of the contact line, known to be independent of topography, does occur. An example is found about a mile south-east of the Little Henry River. However, in no instance is it so strikingly developed as at Kingsgate. Furthermore, other than at Kingsgate, no pipes are associated with these warps of the contact, so far as is known.

The second line of thought involves the established north-north-east to south-south-west trend of the two rich belts at Kingsgate (see Plate 3). If these belts be regarded as "favorable cross structures" such as are very important, although elucidated with difficulty, in many mineral fields, then we have an interesting result. For, if prolonged, they pass through the Comstock area, but not the Pretty Valley area. This affinity of Comstock with Kingsgate seems to be supported also by the metal content of the pipes themselves, whereas the Pretty Valley pipes appear to have been nearly barren of metal as far as mined.

A third consideration involves the fairly obvious deduction from the map that the main productive pipes are situated on the western flanks of synclines or pendants of sediment which project north-westwards into the granite. Thus the Kingsgate, Comstock and Pretty Valley pipes are in a similar environment, and other isolated pipes as at Mount Gibraltar are anomalous. No other pendants were revealed by mapping in the district, though the existence of one in the unmapped area south of the Mitchell River is suspected.
Unsatisfactory as is each of the three foregoing lines of reasoning, taken by itself, we may with some confidence conclude—

(a) So far as the district between Mount Gibraltar and the Mitchell River is concerned, any further prospecting for, and development of, new pipes outside the Kingsgate, Comstock and Pretty Valley areas is inadvisable while development is not at a maximum in the known pipes.

(b) Definite evidence of domes or terraces of the Kingsgate type at Comstock or Pretty Valley is lacking, and to this extent the pipes at the two latter places must be regarded as potentially less productive than have been those in the favorable belts at Kingsgate. The trends of the two Kingsgate structures do, however, pass through Comstock (Plate 3), but not Pretty Valley. There is a possibility that a third such structure, probably parallel, has influenced the Pretty Valley pipes, but, if so, its effect was not seen just south of Kingsgate. From this standpoint, therefore, Comstock would appear to have a superior rating to Pretty Valley. There is little to choose between them on the basis of surface or dump showings of crystal.

3. Other Localities.

On the evidence of dump material or of former miners, pipes have been opened up for inspection or development at Deepwater, Elsmore and Sandy Hill, but although a little crystal was obtained, results were not sufficiently encouraging for work to be continued.

A small amount of crystal has also been won from alluvial sources, as at Kookabookra, 27 miles south-east of Glen Innes.

(iii) Broken Hill.—Clear crystal occurs at several places in this district, but in no instance have specimens of sufficient size been obtained.

(iii) Tarana.—About 5 lb. of usable crystal were obtained from the dump of an old prospecting shaft nine miles from Tarana in the Bathurst district. The shaft was cleaned out and short drives put in on the reef at the 25-foot level, but no further sign of crystal was seen.

C. VICTORIA.

(i) Bendigo.—Some excellent quartz crystals have been produced from the Bendigo gold-field, and some of them are said to have been used for radio purposes. They are, however, very rare, and while an occasional crystal may be found as a result of gold-mining operations, the field offers no inducement for prospecting solely for quartz crystal.

(ii) Kingower (31 miles north of Maryborough).—Some usable quartz has been obtained from a quartz-felspar "pipe" 1 mile south of Mount Kooyoora, and 15 miles south-west of Inglewood. The pipe is at least 50 feet across and occurs in granite. Much of the felspar is kaolinized, as is not uncommon in mineral-bearing pipes. Traces of molybdenite and bismuthinite have been found. The quartz occurs as large irregular grains and also as crystals in vughs. The largest crystal seen was about 18 inches long, although crystals seen at Inglewood, and probably from the same deposit, were even bigger. None of those actually examined contained usable quartz.
More usable quartz may be produced from the Kingower pipe, but on the basis of the quartz recovered from the mining work already done, it cannot be regarded as likely to be an important source of supply.

(iii) Tallangalook.—After this bulletin was originally prepared, attention was drawn to the occurrence of quartz crystals at the Crystal King mine, Tallangalook, about 100 miles north-east of Melbourne. The mine has been visited and reported on by Mr. J. P. L. Kenny, of the Victorian Geological Survey and later by Mr. H. B. Owen, Geologist, of the Bureau of Mineral Resources, Geology and Geophysics.

Quartz crystals occur lining vughs in bodies of massive quartz within aplite pipes in granite. The crystals are smoky-brown in colour and range in weight up to about 300 lb., the average weight being about 10 lb. Two pipes, about 8 feet and 6 feet in diameter respectively, have been discovered and were mined during 1944 and 1945. The two pipes yielded 5 tons of crude crystals from 290 tons of pipe-rock. Twinning and other blemishes in the crystals are common, but the yield of quartz usable for piezo-electric purposes is believed to have been satisfactory.

(iv) Other Localities.-(Bendigo-Castlemaine District).—The gold-quartz reefs of Fryerslown, the Crystal Reef at Tarnagulla, and the Bradford Lead, near Maldon, have all produced a few quartz crystals at some time, but none of them offers much hope of becoming a source of supply of usable crystal.

D. TASMANIA.

(i) Gladstone-Mount Cameron.—This tinfield, 56 miles north-east of Launceston, was the only locality examined.

Twelvetrees (1916, p. 49) mentions the occurrence of quartz crystal in the tin-bearing gravel of Gladstone. It is stated therein that much of the crystal was sold by Chinese collectors to opticians and lapidaries for about 2s. per lb. In recent years a few crystals have found their way to the laboratories of radio firms, but owing to defects, only a small proportion of these has been usable.

The quartz crystals, which are commonly up to a foot in length, have usually a length to breadth ratio of about three to one. They are found sporadically distributed in the tin-bearing alluvium, particularly on the north flank of Mount Cameron. The gravel or alluvium has been worked at intervals over an area of several square miles by the use of water nozzles and sluice boxes. The pebbles have been raked out of the sluice channels and are now found in small heaps scattered over the workings.

The quartz crystals—and the tin—originated in the numerous narrow veins to be found in the granite of Mount Cameron, and in the nearby overlying slate. These veins are not large enough, or rich enough, to be worth mining for either tin or quartz. Furthermore, it is likely that the quartz crystals in the veins would be interlocked with felspar, and thus very difficult to isolate; the felspar has weathered away in the formation of the alluvium. The supply of quartz crystal must come from the old pebble heaps or "hopping" heaps, but may possibly be augmented by a supply from any gravel being newly worked.

The abundance of the quartz varies considerably in the workings. Most of the pebble heaps could be completely examined with the aid of
a pick. None of them is more than a few feet thick, and they usually line the banks of the old sluice channels, into which they could be raked as a convenient method of sorting.

All the crystal found in the tin-bearing gravel is waterworn to some extent. Relatively few specimens were seen in which only the sharp crystal edges have been modified, but commonly the abrasion has been more severe. Some of the pebbles are completely rounded, with no sign of crystal faces. As a rule, however, the Z (or C) axis of the crystal can be determined approximately from the elongation of the pebble.

There are all gradations between clear, transparent crystal and the jet black, opaque type. Most of the specimens are at least smoky. The number of jet black specimens greatly outweighs the number of colourless pebbles for the field as a whole, and the purchase and utilisation of the black quartz must, therefore, be the main consideration in any operations at Gladstone.

Because of the attrition inseparable from this alluvial origin, post-crystallization flaws, as distinct from connate bubble planes and milky zones, are particularly common in the crystals. The exterior surfaces of the pebbles are rough and interfere with a clear view of the quality of the interior. This has brought about the reprehensible practice of breaking the pebbles in the field. Painting the surface of a pebble with methyl salicylate overcomes the difficulty admirably, and should be the method used in the field. Unfortunately, the black quartz remains opaque even when treated in this way, and the presence of flaws can be detected only by removing the colour by heat treatment or by sawing the crystal into thin slabs. Clearing by heat is to be deprecated as a field method, owing to the risk of breakage. In the laboratory, also, the method of slicing the pebble has certain advantages over clearing it by heat.

E. SOUTH AUSTRALIA.

(i) King’s Bluff.—At King’s Bluff, 4 miles west-north-west from Olary, a thick quartzite bed overlies slate, and a group of thin quartz veins traverses the rocks in a north to south direction. The workings for gold, which take the form of adits or shafts underlaying about 30 degrees to the south, have mainly followed the veins along the contact of slate and quartzite. Apparently the best development of the lodes and gold occurred in the quartzite in a zone extending about ten feet above the slate contact. Here the veins expanded and contained vughs of quartz crystals. The deepest shaft is believed to be more than 600 feet on the underlie, and is partly under water at present.

At least two large and apparently suitable crystals were obtained in 1943 from an opening on a vein in the quartzite near the top of the Bluff. One of these is believed to have shown much twinning after cutting and etching, while the other has not been tested. Since the pit has not yet reached the slate-quartzite contact, there is every chance that more crystals will be found on sinking deeper. Besides the two crystals mentioned above, there were others large enough, but too strongly flawed, to be of use. Some of the smaller ones, although clear, showed twinning, particularly of the right- and left-handed variety.
The prospects at King's Bluff are not to be compared with a field such as Kingsgate. Nevertheless, there would be some justification for continuing exploratory work to the point where the crystals might be found to be too rare or too twinned to warrant further development.

(ii) Kirkeek's Treasure Gold Mine.—This mine is 37 miles north of Yunta. The lode has been proved for 600 feet and over this length has an average width of at least 9 feet. Much broken quartz ore lies stacked on the surface. Quartz crystals are common in vughs; the largest crystal seen was 2 inches by $\frac{3}{4}$ inch by $\frac{1}{2}$ inch, but no perfectly clear crystals approaching this size were found. The mine is considered valueless for the production of piezo-electric quartz.

(iii) Wadnaminga Goldfield.—The goldfield lies about 25 miles south-east of Mannahill, and the various mines occur within an area of several square miles. The dumps were examined, special attention being given to the Buffalo Mine, which was the only one showing conspicuous quartz crystals. They occur in narrow belts of "comb structure" parallel to the walls of the lode. The largest crystal found was 3 inches by 1 3/4 inches by 1 inch, but was badly flawed and contained growth lines and milky patches. Even much smaller crystals have a pronounced content of bubbles and flaws. The Wadnaminga field is not considered a possible source of supply because (1) no sign of suitable crystal has been found in the careful examination of large tonnages of quartz from the workings; (2) the crustification or comb structure is not likely to produce crystals much larger than those seen; (3) the crystals are usually interlocked, and below water level occur in a solid matrix of siderite.

(iv) Teetulpa Goldfield.—The district is about 26 miles north-west of Mannahill. A crystal which was apparently suitable for cutting was found here in July, 1943. A north-south group and an east-west group of quartz reefs intersect over an area of several square miles. The workings are shallow and are, for the most part, confined to the reef intersections. Most of the quartz raised is still present in dumps; apparently only hand-picked ore was crushed.

Although at least one apparently suitable crystal has been obtained, development of the field for crystal is not warranted. Examination of the large tonnage of quartz exposed indicates that the proportion of crystal approaching usability is extremely small. Below water level, which is very shallow, any crystals present will be sealed in a matrix of siderite and their examination or extraction will be impracticable. Signs of twinning were conspicuous in most of the small crystals found on the field.

(v) The Prince Albert Copper Mine.—This mine, 14 miles north-east of Adelaide, was examined. However, the veins and workings are of very small size. Quartz crystals seen did not exceed a quarter of an inch in length.

(vi) Mount Lofty Quarries.—The Mount Lofty quarries, 4 miles south-east from Adelaide, have yielded quartz crystals from time to time, and a few have been usable. They occur in small veins in quartzite. There is no prospect of obtaining more crystals by a specific plan of work, as their occurrence is very rare. An occasional crystal will probably be found from time to time during quarrying operations.
(i) Goomalling.—This is the most promising locality for crystal in Western Australia. On the wheat property of Mr. J. J. White, Oaks Park, near Goomalling, a large crystal weighing 43 lb. was brought to light while ploughing. Amalgamated Wireless (A/asia) Ltd., reported that it was almost 100 per cent. usable, and one of the best Australian crystals yet seen.

Except for a few fragments of quartzite in the next paddock, there is no rock outcrop for a great distance from the find. As the large crystal, and other smaller ones occurring with it, are only very slightly eroded, it appears that they are derived either from a reef immediately underlying the soil at the find, or from a layer of gravel wash which has made its way down the gentle hill slopes from a concealed outcrop at some higher elevation. There is no certainty that the present hill slopes correspond in detail with the slopes at the time of formation of the subsoil wash.

As the likelihood of obtaining further crystals is strong, the occurrence should be adequately tested. The soil is most unlikely to exceed 10 feet in depth, and will probably be only a few feet. The best method to explore the ground would be to use a tractor and scoop, and to rake or coarsely sieve the soil removed. Enough scooping should be done to determine—

(i) Whether the quartz is in situ as a lode or has travelled in wash.

(ii) The trend of the deposit, if it occurs as wash.

(iii) The proportion of usable quartz present.

(ii) Morowa.—Sixteen miles west of Morowa, Mr. H. A. Frank has pegged out two blocks for quartz crystals. One of them adjoins the main road and the second block is 2 miles further north.

On the southern block is a well, sunk twenty years ago near Mr. Hightman's homestead. According to Mr. Frank, who sank the well, a layer of crystals was found at a depth of 69 feet, the surrounding rock being a soft white clay. The well was continued to 84 feet. The well is now closely timbered. Although a good deal of the dump has been removed, the remainder shows occasional small single or interlocking clear crystals. Mr. Frank states that much larger crystals are to be found in the seam or vein. The fresh faces on the crystals, and the presence of delicate aggregates with flat cavities from which calcite or similar mineral has been dissolved, suggest that the seam is not alluvial, but is a vein, the surrounding country rock having been weathered to a soft clayey mass. The occurrence merits investigation.

The northern block has produced several good crystals with very little twinning; however, they have been barely of sufficient size. They were obtained from a small gully or creek channel, and were derived from the erosion of a series of Pre-Cambrian quartzites and lavas. The crystals occur in very narrow and non-persistent veins in the quartzite; the veins are rare. The occurrence resembles that of the crystals in the quartzite of the Mount Lofty Ranges, near Adelaide, where occasional crystals have been found, but only in the course of mining large tonnages of quartzite. At Morowa also, crystals could be obtained only by mining large tonnages of rock. Even then, the chance
of finding crystals large enough to use would be negligible. The several crystals found in the creek undoubtedly represent the product of erosion of thousands of cubic yards of quartzite. Further work on this block is not warranted.

(iii) Payne's Find.—Crystals have been reported from one shaft on the Orchid Lease at Payne's Find, 86 miles south-east of Yalgoo. According to correspondence received by the Mines Department, all the crystals occurred above the 300 foot level, and none was above 2 lb. in weight. E. de C. Clarke (1925, page 33), in his bulletin on the field, mentions that a large vugh was met with in the shaft.

The lodes at Payne's Find are of small size, and are quartz veins in gneiss; pegmatite-filled faults offset the veins. Apart from the reported vugh on the Orchid Lease, and the presence of several fragments of cloudy crystal near the shaft, there is little to suggest the occurrence of quartz crystal in the lodes. The dump from the shaft which encountered the vugh contains about 100 tons of rock, but no crystal was visible at the surface.

It is probable that the crystals which have come to attention recently were abnormally good specimens which had been preserved as curios when the mine was being worked. They are stated locally to have barely exceeded 1 inch in diameter, and their quality is unknown. Unless clear or large crystals are found in the dump, which appears unlikely, it is not advisable to unwater the shaft for inspection.

(iv) Kalgoorlie District.—Specimens at the School of Mines, Kalgoorlie, include crystals of quartz up to 5 inches by 2 inches, from the local mines. These are not clear, and are apparently very rarely found. The lodes at Kalgoorlie are such that quartz crystals cannot be expected normally, but the large scale of operations has resulted in the production of an occasional usable specimen. In this respect, the field resembles Bendigo.

Burbanks, Goongarrie, the Londonderry felspar quarry and the Phoenix Gold Mine at Coolgardie, all in the Kalgoorlie district, were also briefly investigated. None offers promise as a potential producer of crystal.

6. REFERENCES.

Broken Hill, N.S.W.
31st August, 1947.
### APPENDIX.

**SCHEDULE OF PIPES, KINGSGATE.**


<table>
<thead>
<tr>
<th>No.</th>
<th>Known as—</th>
<th>Length worked on Pipe exclusive of Branches</th>
<th>Average Size of Pipe in bottom at end of Year 1911</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Quinn's Find</td>
<td>*</td>
<td><strong>3 pipes 10 x 10 each (approximate)</strong></td>
</tr>
<tr>
<td>2</td>
<td>No. 6</td>
<td>50 ft. (approximate)</td>
<td>1 in 2</td>
</tr>
<tr>
<td>3</td>
<td></td>
<td></td>
<td><strong>3 pipes 10 x 10 each (approximate)</strong></td>
</tr>
<tr>
<td>4</td>
<td></td>
<td>40 ft. (approximate)</td>
<td>Vertical</td>
</tr>
<tr>
<td>5</td>
<td>One and Nine</td>
<td>282 ft.</td>
<td>1 in 2</td>
</tr>
<tr>
<td>6</td>
<td></td>
<td></td>
<td>25 x 15</td>
</tr>
<tr>
<td>7</td>
<td>Water Shaft (or Tin Show)</td>
<td>40 ft. (approximate)</td>
<td>Vertical</td>
</tr>
<tr>
<td>8</td>
<td>Black Shaft (or 26 East)</td>
<td>311 ft.</td>
<td>1 in 2</td>
</tr>
<tr>
<td>9</td>
<td>Bill Miller's Hole</td>
<td>33</td>
<td>Vertical</td>
</tr>
<tr>
<td>10</td>
<td>Old 26 (or Little Tunnel)</td>
<td>100 ft. (approximate)</td>
<td>1 in 2</td>
</tr>
<tr>
<td>11</td>
<td>Mick's Shaft</td>
<td>100 ft. (approximate)</td>
<td>1 in 1</td>
</tr>
<tr>
<td>12</td>
<td>26 North</td>
<td>*</td>
<td><strong>15 x 20</strong></td>
</tr>
<tr>
<td>13</td>
<td>Old 25</td>
<td>500 ft. (approximate)</td>
<td>1 in 2</td>
</tr>
<tr>
<td>14</td>
<td>Weidmeyer's Cutting</td>
<td>250 ft.</td>
<td>1 in 1</td>
</tr>
<tr>
<td>15</td>
<td>Martin's Hole</td>
<td>100 ft.</td>
<td>Vertical</td>
</tr>
<tr>
<td>16</td>
<td>Schoolhouse Blow</td>
<td>50 ft.</td>
<td>Vertical</td>
</tr>
<tr>
<td>17</td>
<td>Magazine (or Windlass Shaft)</td>
<td>*</td>
<td><strong>12 x 12</strong></td>
</tr>
<tr>
<td>18</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>19</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>21</td>
<td>28 South (below road)</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>22</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>23</td>
<td>Forty North</td>
<td>200 ft. (approximate)</td>
<td>1 in 1</td>
</tr>
<tr>
<td>24</td>
<td>Forty</td>
<td>300 ft. (approximate)</td>
<td>Vertical</td>
</tr>
<tr>
<td>25</td>
<td>Forty South</td>
<td>60 ft. (approximate)</td>
<td>Vertical</td>
</tr>
<tr>
<td>26</td>
<td>Jim Marshall's Hole</td>
<td>*</td>
<td><strong>16 x 13</strong></td>
</tr>
<tr>
<td>27</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>28</td>
<td>Arsenic Blow</td>
<td>250 ft. (approximate)</td>
<td>1 in 2</td>
</tr>
<tr>
<td>29</td>
<td>Hard Blow</td>
<td>50 ft.</td>
<td>Vertical</td>
</tr>
<tr>
<td>30</td>
<td>Sachs' Folly</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>31</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>32</td>
<td>25 West</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>33</td>
<td>25 South</td>
<td>35 ft.</td>
<td>Vertical</td>
</tr>
<tr>
<td>34</td>
<td>Mt. Morgan</td>
<td>225 ft.</td>
<td>1 in 2</td>
</tr>
<tr>
<td>35</td>
<td>Granite Shaft</td>
<td>150 ft. (approximate)</td>
<td>1 in 1</td>
</tr>
<tr>
<td>36</td>
<td>25 N.W., No. 2</td>
<td>50 ft.</td>
<td>1 in 1</td>
</tr>
<tr>
<td>37</td>
<td>Tom Key's Hole (or Chimney Shaft)</td>
<td>150 ft.</td>
<td>1 in 1</td>
</tr>
<tr>
<td>38</td>
<td>25 South, No. 2</td>
<td>32 ft.</td>
<td>Vertical</td>
</tr>
<tr>
<td>39</td>
<td></td>
<td></td>
<td>12 x 12 (approximate)</td>
</tr>
<tr>
<td>40</td>
<td>Jubilee</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>41</td>
<td>Road Block</td>
<td>60 ft.</td>
<td>1 in 1</td>
</tr>
<tr>
<td>42</td>
<td></td>
<td></td>
<td>8 x 8</td>
</tr>
<tr>
<td>43</td>
<td>Christie's Blow</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>44</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>45</td>
<td>Jack's at home</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>46</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>47</td>
<td>Swamp Blow</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>48</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>49</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>50</td>
<td>Nield's Blow</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>51</td>
<td>Reef Blow</td>
<td>*</td>
<td></td>
</tr>
</tbody>
</table>

* Prospected on surface only. † Worked along footwall only. ‡ Three additional pipes have been found in the southern portion of Block 24 during 1916.

**NOTE.**—Deposits 17, 25, 36 and 46 are omitted on Plate 2 being no longer identifiable.

*By Authority: L. F. JOHNSTON, Commonwealth Government Printer, Canberra.*
MAP SHOWING PRINCIPAL LOCALITIES FOR PIEZO-ELECTRIC QUARTZ IN AUSTRALIA

- Reference:
  - 1. Palmer River
  - 2. Wollemi Camp
  - 3. Petford
  - 4. Croydon
  - 5. Duck Creek
  - 6. Marrinah
  - 7. Wondah Knob
  - 8. Standhora
  - 9. Despater etc.
  - 10. Kingsvale
  - 11. Kookaburra
  - 12. Broken Hill
  - 13. Tarana
  - 14. Bendigo
  - 15. Kandawer
  - 16. Gladstone - Mt Cameron
  - 18. Tegulae
  - 19. King's Bluff
  - 20. Northallinga
  - 21. Adelaide District
  - 22. Minervoa
  - 23. Paynes Find
  - 24. Kalgoorlie District
  - 25. Goomalling & Tallangalook

Names of principal localities in which usable or nearly usable quartz crystals have been found are underlined.
KINGSGATE QUARTZ CRYSTAL FIELD

REFERENCE

○ PIPES WITH GOOD CRYSTAL PROSPECTS
□ = POOR
□□ ZONES OF MOST PRODUCTIVE PIPES
□□ GRANITIC ROCK
□□ SEDIMENTARY ROCKS

NUMBER & LETTER DESIGNATION OF PIPES
1-28 (NO. 29, 30, 31 & 32 OMITTED, BEING NO LONGER IDENTIFIABLE) = AFTER E.C. ANDREWS MIN RES. GEOLOG. SUR. N.S.W. NO. 24, PLAN FACING P 94 & PP 100-104.
A-J & NAMED PIPES
A-J = DITTO
M-U = ADDITIONAL PIPES MAPPED DURING PRESENT SURVEY

ZONE I

ZONE II

PLATE 2.
<table>
<thead>
<tr>
<th>No.</th>
<th>Mineral</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Zirconium</td>
</tr>
<tr>
<td>2</td>
<td>Titanium—Rutile and Ilmenite</td>
</tr>
<tr>
<td>3</td>
<td>Antimony</td>
</tr>
<tr>
<td>4</td>
<td>Mica</td>
</tr>
<tr>
<td>5</td>
<td>Graphite</td>
</tr>
<tr>
<td>6</td>
<td>Fluorite (Fluorspar) and Cryolite</td>
</tr>
<tr>
<td>7</td>
<td>Manganese*</td>
</tr>
<tr>
<td>8</td>
<td>Molybdenum</td>
</tr>
<tr>
<td>9</td>
<td>Bismuth</td>
</tr>
<tr>
<td>10</td>
<td>Chromium*</td>
</tr>
<tr>
<td>11</td>
<td>Magnesium—Magnesite, Dolomite, &amp;c.</td>
</tr>
<tr>
<td>12</td>
<td>Diatomite</td>
</tr>
<tr>
<td>13</td>
<td>Barium—Barite or Barytes</td>
</tr>
<tr>
<td>14</td>
<td>Felspar (including Cornish Stone)</td>
</tr>
<tr>
<td>15</td>
<td>Talc, including Steatite, Pyrophyllite, &amp;c.*</td>
</tr>
<tr>
<td>16</td>
<td>Tungsten*</td>
</tr>
<tr>
<td>17</td>
<td>Asbestos</td>
</tr>
<tr>
<td>18</td>
<td>Beryllium</td>
</tr>
<tr>
<td>19</td>
<td>Tantalum and Columbium</td>
</tr>
<tr>
<td>20</td>
<td>Mercury</td>
</tr>
<tr>
<td>21</td>
<td>Cadmium*</td>
</tr>
<tr>
<td>22</td>
<td>Arsenic</td>
</tr>
<tr>
<td>23</td>
<td>Lead*</td>
</tr>
<tr>
<td>24</td>
<td>Pigment Minerals*</td>
</tr>
<tr>
<td>25</td>
<td>Lithium</td>
</tr>
<tr>
<td>26</td>
<td>Sillimanite, Kyanite, &amp;c.</td>
</tr>
<tr>
<td>27</td>
<td>Aluminium and Bauxite</td>
</tr>
<tr>
<td>28</td>
<td>Uranium and Radium†</td>
</tr>
<tr>
<td>29</td>
<td>Phosphates*</td>
</tr>
<tr>
<td>30</td>
<td>Bentonite and Fuller’s Earth</td>
</tr>
<tr>
<td>31</td>
<td>Sulphur, including Pyrite and other sulphur-bearing minerals*</td>
</tr>
<tr>
<td>32</td>
<td>Cobalt*</td>
</tr>
<tr>
<td>33</td>
<td>Zinc*</td>
</tr>
<tr>
<td>34</td>
<td>Potash Minerals*</td>
</tr>
<tr>
<td>35</td>
<td>Minor Metals*</td>
</tr>
</tbody>
</table>

* To be published shortly.
† Not available for publication at present.