Tasmania

DEPARTMENT OF MINES

GEOLOGICAL SURVEY BULLETIN

No. 17

The Bald Hill Osmiridium Field

BY

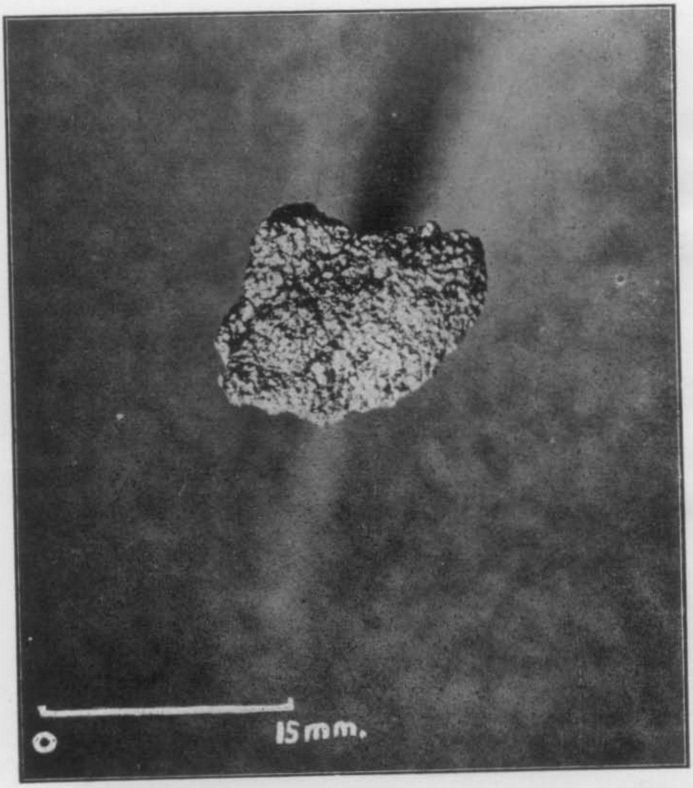
W. H. TWELVETREES, Government Geologist

Issued under the authority of
The Honourable J. E. OGDEN, Minister for Mines

Tasmania:
JOHN VAIL, GOVERNMENT PRINTER, HOBART

1914

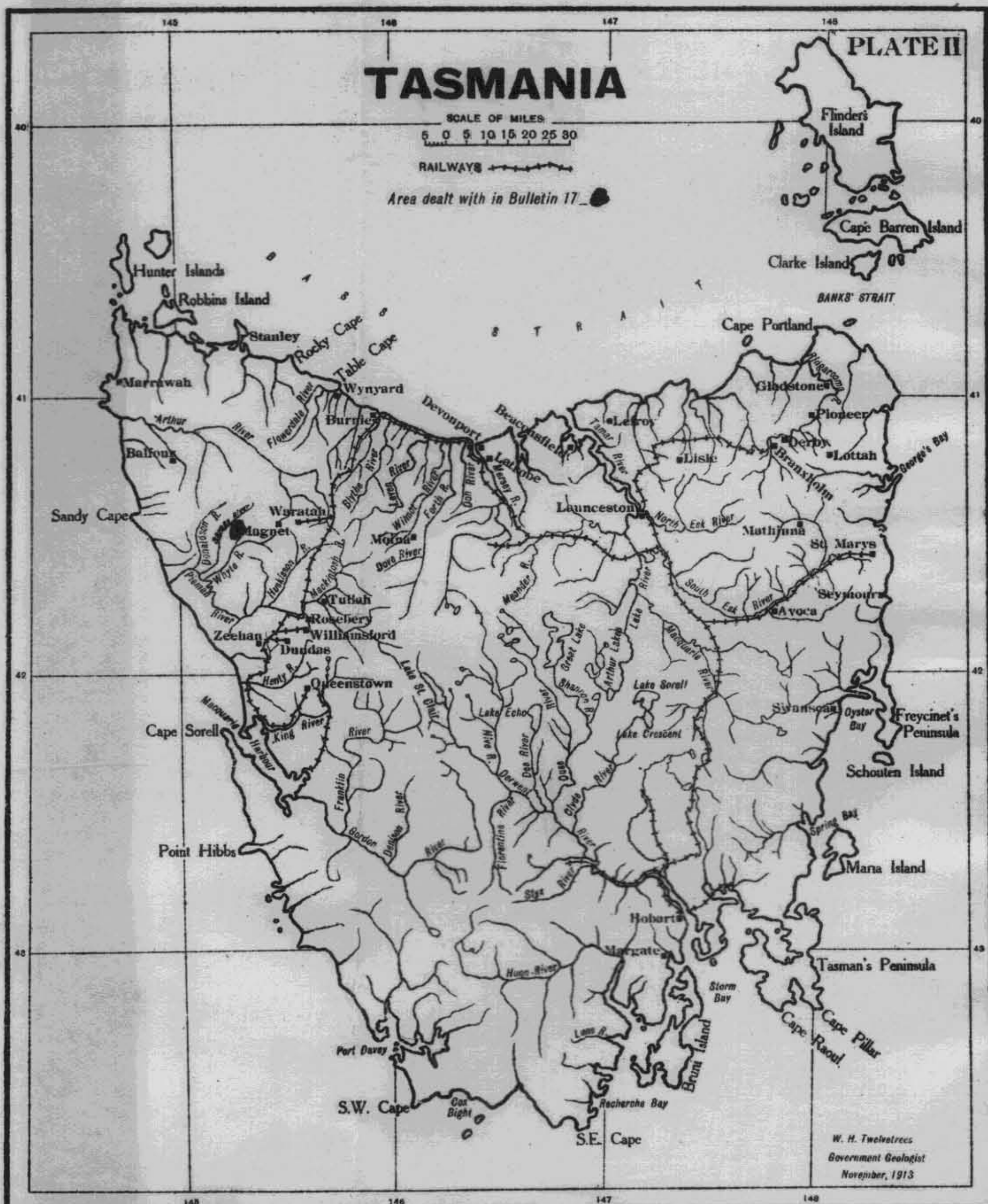
NUGGET OF OSMIRIDIUM.



Weight, 9 dwts.

TABLE OF CONTENTS.

ILLUSTRATIONS.



LOCALITY MAP

Photo Algraphed by John Vail Government Printer Hobart Tasmania

The Bald Hill Osmiridium Field.

I.—INTRODUCTION.

The increasing output of the rare mineral osmiridium (or iridosmine, as it is more frequently termed in mineralogical text-books) in Tasmania, and its detection in undisturbed rock on the summit and western slope of the Bald Hill in the Heazlewood district, have recently attracted much attention, not only here, but also outside the State. The remunerative market prices have stimulated alluvial mining, and numerous applications for leases have been made by parties anxious to embark on stone mining for this mineral.

The south end of the field in this district is skirted by the road from Waratah to Corinna at from 15 to 19 miles from the former township. This road at the Bald Hill is a winding sideling of good grade to about half a mile beyond Alford's Creek. At this point the metalled road comes to an end, and only a pack-track crosses the Long Plain till it joins the road again at 12 miles from Corinna. This latter portion of the road was constructed in 1900, but owing to the non-renewal of the Parliamentary vote at that time work on it was suspended, and there is still the 8 miles gap between the two ends of the road. In addition, the Corinna portion of the road is now being somewhat encroached upon by growing scrub, through which horses have to push their way.

In travelling to the Bald Hill field, the Whyte River settlement is passed at 10 miles out from Waratah. There are a store, hotel, and a few cottages, but no post-office, consequently residents at the Whyte River and the workers at the Heazlewood and Whyte River mines, besides those on the osmiridium field, have to depend for their mails on store carts and other opportunities from Waratah. In view of the mining which is going on in the district, it is a pity that better postal facilities are not provided.

Three miles beyond the Whyte, the deserted huts of the old Heazlewood township are passed. Two miles further west, or a little over 15 miles from Waratah, the road passes by the new ore concentrating mill belonging to the Mt. Jasper Copper Mines, No Liability, and crosses the Heazlewood River at about 800 feet above sea-level.

Immediately beyond the bridge it begins its course as a sideling road, winding its way westwards round the southern end of the Bald Hill for $3\frac{1}{2}$ miles. Here the western side of the hill is reached at a small saddle (called the Nineteen Mile), from which creeks flow north into the Nineteen Mile Creek system and southwards into the Heazlewood River.

The old store marked at this spot on the Long Plain mineral chart has long since been destroyed. A hut exists, however, on the south side of the road. It may be mentioned here that the mileages on the Government chart of mineral sections refer to miles counted from Corinna, and not from Waratah. The distance between these two places is 40 miles 20 chains.

The road beyond the Nineteen Mile continues southwards through a belt of timbered country for $1\frac{1}{2}$ mile, after which it merges into the pack-track on the Long Plain.

A foot track from the Nineteen Mile passes through the scrub northwards for about a mile to the osmiridium claims situate on the Nineteen Mile Creek and its tributaries, Linger-and-Die and McGinty's Creeks. About a mile to the west the Nineteen Mile Creek joins the Savage River, which flows south-westerly into the Pieman, just below Corinna. The Nineteen Mile Creek for a considerable portion of its course may be said to skirt the foot of the western slopes of the Bald Hill. The Linger-and-Die, McGinty's, and other creeks which flow into it from the east, head from the steep western front of the Bald Hill itself.

The claims at the northern end of the field are reached by a roughly-staked track leading over the top of the hill from the main-road at about $17\frac{1}{2}$ miles from Waratah (between 22 and 23 miles from Corinna, as marked on the Government plan). A bullock's skull is mounted on a stake as a guide to the turn-off up the hill. The Bald Hill is a flat-topped ridge of serpentine rock covered with button-grass, extending $2\frac{1}{2}$ miles north-east—south-west, and about a mile wide. This broad tableland receives an ample share of the rainfall, which is in the neighbourhood of 7 feet per annum. Except, perhaps, in the height of summer, the surface soil is wet, as the configuration of the summit does not admit of rapid drainage. Clumps of peppermint occur at intervals, where the ferruginous soil is favourable for the growth of trees, and the northern end of the hill is pretty freely covered with timber. At this end the Bald Hill proper descends to form a small saddle, from which creeks flow west into the Nineteen Mile Creek and east (Roaring Meg) into the Heazlewood River. The continuation of the range runs roughly parallel with the Nineteen Mile Creek, which is still the western border of the serpentine country. This northern end of the field can also be reached by a short cut west of the Heazlewood bridge. Another track could also be made down the valley of the Thirteen Mile Creek to the Heazlewood township.

II.—PHYSIOGRAPHY.

The Bald Hill forms the divide between the Nineteen Mile Creek and the Heazlewood River, with its steepest fall towards the former. As one stands on the summit, one sees to the south-west the monotonous treeless plateau of the Long Plain in the distance, and one becomes aware from the general level of the surrounding country that one is on part of an extensive peneplain, which is being dissected by the streams which have cut their channels and formed their gorges in comparatively recent times. The Nineteen Mile Creek and its tributary streams certainly belong to this category. The Heazlewood River is, perhaps, a little older, though still geologically young. It empties its waters into the Whyte, which commenced to flow subsequently to the deposition of the Tertiary drifts, the remnants of which are now to be seen on the road between the Nineteen Mile hut and the Long Plain. These drifts contain granitic sand, which must have been transported here by a river heading from the Meredith Range before the existence of the Whyte and Heazlewood rivers.

The general level of the Bald Hill plateau and the higher parts of the Long Plain is about 1600 feet above sea-level, and its uniformity denotes an old worn-down surface (a peneplain), since elevated, and now being remoulded by the agencies of a new cycle of erosion. The Bald Hill itself is being shaped into greater relief by the corrosive action of the streams which fringe three sides of it; and the hard siliceous lodes which outcrop on its summit, in resisting the forces of erosion, have a controlling influence on its topographic form.

III.—GENERAL GEOLOGY.

The geology of the Bald Hill possesses a certain uniformity, as it is restricted to that of the serpentinised rocks which fringe the northern and eastern boundaries of the granite of the Meredith Range.

The granite and the serpentinised peridotites and pyroxene rocks belong to the Devonian period. There is evidence, however, that they were not synchronous in their consolidation; the basic rocks had solidified before they were invaded by the acid magma.

The basic eruptives have intruded into the Pre-Silurian slates and sandstones, and even into the Silurian sandstone, as may be seen above the road east of the Mt. Jasper stables.

The Bald Hill is near the northern end of a strip of serpentine extending about 30 miles from north to south, and from 2 or 3 to 4 or 5 miles from east to west. This exposure of serpentine has been traced for 7 miles north of the Waratah-Corinna-road. Mr. T. H. Jones found colours of osmiridium as far north as 5 or 6 miles north-east of Mt. Cleveland, in a creek falling east into the Arthur River. Southwards it continues across the Whyte and Castray Rivers along David Jones' track, until it is interrupted by a spur of granite from the Meredith Range. It reappears on the south side of the spur at the head waters of the Little Wilson River, east of the Parson's Hood, and passes further south to the Huskisson and Pieman Rivers, and thence on to the Dundas and North Dundas districts.

An incomplete fringe of serpentinised rocks is thus developed along the eastern boundary of the Meredith Range batholith. Sometimes this fringe is in close contact with the granite at surface, or again it is at some distance from the exposed margin of it; and it continues both north and south for several miles beyond any exposure of granite rock. These occurrences illustrate the tendency of some granite masses to show successive differentiation zones, becoming more basic towards the periphery of the batholith, until finally the outermost margin is developed as gabbro or peridotite (subsequently serpentinised).

Prof. E. Weinschenk's remarks on this in his "Elements of Petrology" are apropos:—

"In granitic stocks it often appears that the core of the massif consists of a two-mica granite, which in passing outwards gradually loses its muscovite content; the rock becomes biotite-granite, and amphibole also enters as a constituent, the proportion of plagioclase felspar becomes more considerable, and at last strictly plagioclastic rocks (diorite and even gabbro) come in and represent facies of the granite."

The above, however, refers to differentiation in place, whereas the Meredith Range phenomena show an early consolidation of the basic part of the magma, completed before that of the acid granitic portion, which in places even invaded the already formed basic mantle. At the Bald Hill it is in the outermost ultra-basic fringe that the osmiridium resides.

West of the old Heazlewood township is a belt of green actinolitic contact-metamorphic rock about half-a-mile wide, lying between Pre-Silurian syenite and the serpentine. This rock contains a little quartz, and the material for the actinolite must have been derived from the hornblende mineral in the syenite. It is unusual, however, for either this syenite or the neighbouring basic rock to produce such marked contact-metamorphic effects. An explanation might be that the metamorphism is due to the proximity of concealed Devonian granite.

On the western side of the Bald Hill the serpentinised rocks impinge on soft, grey and dark slates, without any metamorphic action. The slates weather in various shades of yellow. In some places they are purple and ferruginous, and at one spot near the contact at the Nineteen Mile Creek a certain amount of induration has been produced. These slates may be interpreted as belonging to the Dundas series, and as of Pre-Silurian age. They strike north 5 to 20 degrees east, and their general dip is north-west. The series continues southwards from the Bald Hill, and west of the Nineteen Mile Creek, across the Long Plain to 14 miles from Corinna, where it gives place to the Rocky River amphibolitic schists. Along the track for this distance numerous lithological varieties occur—indurated sandstone, laminated quartzite, thinly-bedded arenaceous clay slate, and intercalated porphyroids. The last-mentioned appear about a mile south of the turn-off to the Rio Tinto.

Apart from a little patch of basalt at the Nineteen Mile, most of the primary rocks of the Bald Hill are the ultra-basic terms of the gabbroid division. They may be classified as follows:—

Peridotites = olivine rocks without felspar.

Name.	Mineral Composition.
Harzburgite.......	Olivine + orthorhombic pyroxene (enstatite or bronzite).

Pyroxenites = rocks consisting essentially of pyroxene.

Name.	Mineral Composition.
Bronzite or Enstatite rock..	Bronzite or enstatite, orthorhombic pyroxenes.

In some parts of the belt a little saussurite-gabbro occurs, particularly in the eastern part of the field.

These peridotites and pyroxenites represent extremely basic developments of the gabbroid magma from which the felspathic constituent has disappeared. Where the serpentinisation process has been incomplete, bronzite or enstatite is greatly in evidence. The most basic variety is the pyroxenite occurring near the Bullock's head turn-off near the Eighteen Mile and along the road towards the Nineteen Mile. This rock, where it is at all fresh, appears to the naked eye to be composed of dark-brown pyroxene in lustrous plates from $\frac{1}{4}$-inch to $\frac{1}{2}$-inch diameter. It weathers with a rusty brown crust. Microscopical examination shows that an orthorhombic pyroxene is the sole mineral in the rock, the extinctions being parallel with and perpendicular to the longitudinal cleavage directions. This pyroxene is a pale bronzite with a scarcely perceptible pleochroism. The distinction between bronzite and enstatite is not a very precise one, based, as it is, on the fact that the latter is slightly less ferriferous than bronzite. Minute serpentinous veins traverse the rock.

The orthorhombic pyroxene bronzite or enstatite is visible in the rock all over the hill wherever serpentinisation has not proceeded too far. A good deal, however, of what appears to be purely bronzite rock contained at one time olivine in addition to the pyroxene mineral, the olivine having been obliterated by the serpentinising process.

The hard rock on the road near the Nineteen Mile hut is a dark, mottled harzburgite, considerably serpentinised and containing a good deal of magnetite. The lightercoloured crystals in it are enstatite. The darker patches are serpentinous; under the microscope these are seen to be crystals of olivine cut up into separate areas by invading serpentine. Along the lines of the resulting meshwork secondary magnetite from the decomposing olivine has been deposited.

The serpentine rock, which is seen everywhere, is the hydrated derivate from the anhydrous peridotites and pyroxenites. The formation of the serpentine mineral starts along the microscopic cracks of the crystals of olivine (or more rarely of pyroxene) in the unaltered rock, producing gradually a meshwork of fibrous serpentine accompanied by a separation of the iron of the olivine or pyroxene mineral as an oxide.

The hydration has often been described as being due to weathering, but this view must be regarded with doubt. The weathering process is essentially a superficial one. The serpentine rock may be seen in the Lord Brassey Nickel Mine, east of the Bald Hill, 100 feet below the surface, in a tunnel which has been driven 600 feet into the hill, and it could probably be followed down indefinitely. On the other hand, the olivine (a mineral which is appealed to as weathering to serpentine with extreme readiness) in the weathered Tertiary basalt at the south end of the Bald Hill is quite fresh and unaltered. There are good reasons for supposing serpentinisation to be a deep-seated thermal process. On this hypothesis, the Bald Hill serpentine is a product of the after-action of the gabbro-peridotite consolidations; and the opalisation and chalcedonisation of the rock may be attributed to the same cause, but later than the serpentinising process.

Basalt.

East of the Nineteen Mile hut is a double knob of Tertiary basalt, which crowns the hill at 300 feet above the road. This patch is timbered with peppermint and covered with dogwood scrub and fern. McGinty's old garden at the summit is on the dark-red soil derived from this rock. The basalt is the ordinary olivine-bearing variety, and is greatly decomposed. Its texture is not coarse, and there is nothing in the aspect of the rock which would indicate whether it is a volcanic neck or a denuded survival of a former lava flow. Basalt also exists north of the Bald Hill, on the east side of the Nineteen Mile Creek.

Mineralogy of the Serpentine.

Most of the metallic minerals in the serpentine were also primary minerals in the parent rock. These are magnetite, chromite, pyrite, pyrrhotite, nickel, gold, osmiridium.

Magnetite.—This is an isometric mineral, and its black crystals with metallic lustre, when too small to apply physical tests, are difficult to distinguish from chromite by mere inspection. It is strongly attracted by the magnet, and unlike chromite it is soluble in acid. It is a primary constituent of the eruptive rock, but it occurs also as a secondary mineral, in veinlets and otherwise, in the serpentine, derived in the latter case from the decomposition of the ferro-magnesian minerals. The mineral is present also in the veins of opaline and chalcedonic silica, which are met with in the serpentine. When primary, it has probably been mechanically involved in these; more often it has resulted from the decomposition of the olivine.

Chromite.—This mineral crystallises in the same system as magnetite, and has been believed by many to have been liberated during the process of serpentinisation, especially as the large commercial deposits of the ore occur invariably in serpentinised rock. It has been found, however, in quite fresh peridotite, and its remarkable natural insolubility points to its occurrence in serpentine as that of a residual mineral which has survived the process of hydration. The chromium was a constituent of the parent rock magma, and separated out early during the cooling of the latter.

The chromite occurs as isolated crystals or as small groups of crystals disseminated through the serpentine, and is nowhere present in quantities sufficient for exploitation. It also occurs with magnetite in the opaline veins referred to above.

The most basic and insoluble elements of the molten magma would crystallise in the outer and cooler portions of its mass. This explains the prevalence of chromite and osmiridium in the western marginal part of the Bald Hill serpentine. Currents and movements in the magma would be agents competent to effect the transport of continual fresh supplies of these minerals to the peripheral portion of the magma reservoir.*

* See the Occurrence, Origin, and Chemical Composition of Chromite, by J. H. Pratt, Trans., A.I.M.E., vol. xxix., p. 26.

Examination has shown that the chromite often either encloses osmiridium or is intergrown with it. Chromite and platinum are known elsewhere to have crystallised together in grains or nuggets, and when working platiniferous sands an abundance of the former mineral is always looked upon as a good indication. The same seems to hold good in our alluvial osmiridium deposits, and osmiridium prospecting should not be neglected in fields where chromite is plentiful.

Pyrite.—Veinlets of white pyrite occur in the altered serpentine associated with the lodes, and this mineral was at first mistaken locally for osmiridium.

Pyrrhotite (Magnetic Iron Pyrites).—Bronze-coloured veinlets of this mineral (with traces of nickel) intersect the altered serpentine on the summit of the Bald Hill, and appear also to be present in the gossanous outcrops of the chalcedonic lodes there. It is also irregularly distributed in the serpentine-chalcedony formation in the form of small patches, nests, and strings.

This mineral is one which belongs to the magmatic period, though in these veins it would seem to have been deposited at a late stage in that period. The veins will be found to be restricted to the serpentine, but will not pass into the surrounding sedimentary strata.

Nickel is a characteristic associate of pyrrhotite in basic rocks, and minute proportions of the platinum metals also occur occasionally with nickeliferous sulphide. The veinlets of pyrrhotite in Purcell's lode have been found by the Government Analyst to contain traces of nickel, and they thus fall into line with occurrences of nickeliferous sulphides elsewhere.

An interesting occurrence is that recorded in Cape Colony, South Africa,* where copper-nickel ores are present at and near the contact of gabbro and allied basic rocks with the Karoo sandstones. These ores contain pyrrhotite, pentlandite, niccolite, chalcopyrite, and bornite. They have a platinum content varying from 12 gr. to 4 oz. 19 dwt. per ton; and traces of gold, silver, cobalt, and osmiridium are reported.

Gold.—This metal is evidently a primary constituent of the eruptive rock, for it may be seen facing the cleavage surfaces of the grains of osmiridium as if welded on to them, or even intergrown with them.

Osmiridium.—This occurs as small grains in serpentine, as described later in this bulletin.

* Copper-nickel Deposits of the Insizwa by A. L. Du Toit, Dept. of Mines, Cape of Good Hope, 1911.

IV.—OSMIRIDIUM MINING.

The sands of the Savage River and its tributaries were worked for gold as far back as 30 years ago. Osmiridium was not in demand at that time, and the diggers used, in fact, to regard it as a nuisance when it remained behind with their gold, for the latter could be separated only by amalgamation. About 15 years ago the market price of the despised mineral went up from 30s. to 50s. per oz., and parties of men began working the Savage River sands for osmiridium. They gradually extended up the river, and McGinty, the veteran prospector, is supposed to have been the pioneer at the Nineteen Mile.

The mineral in the Savage River obviously came from the Nineteen Mile Creek. This creek and the tributaries which flow into it from the Bald Hill have been worked by alluvial miners in increasing numbers as the market rates steadily advanced. The summer before last 150 men were on the Savage River and Nineteen Mile fields, and last summer about 65 men worked at the south end of the latter. This winter there were 18 men at the south end and 13 at the north end, but those at the Savage always have to give up work for the wet season. The present price realised by miners for their product is £10 17s. 6d. per oz.; and at this figure a very small daily quota of mineral makes ground payable.

Several creeks flow rather steeply from the western side of the Bald Hill into the Nineteen Mile Creek. These have received local names, such as Linger-and-Die, McGinty's, Barren Creek, &c. Their head waters have their sources in cirques or amphitheatres hollowed out in the steep wall of the hill front. McGinty's Creek is the most important of these torrential streams, and has been the largest contributor of mineral. Its upper part, however, does not seem to have been payable. The descending rubble of angular and subangular detritus carried by these creeks often rests on a layer of "cement," which is hard enough to require blasting. The mineral for the most part lies on the bottom, though a good deal is recovered by washing the superficial material. McGinty's Creek yields shotty as well as fine osmiridium; specks as heavy as 14 grains have been obtained in shooting up the bottom. The next best creek is the Linger-and-Die, which has produced a fair quantity of mineral in its time, but it has apparently seen its best days. The mineral found in it used all to be small and round when McGinty worked there, but the present workers have obtained some 5-grain specks. The next creek north of McGinty's (Barren Creek) has yielded only a few colours towards its mouth, but nothing payable.

The general way of winning the mineral is to pick or blast up the creek bottom and empty the stone into riffled sluice-boxes. The bottom has sometimes to be broken up to the depth of a foot or more in order to get the mineral which has settled into the crevices of the rock. The same conditions obtain in the platinum gravels in Russia, where the serpentinous bottom is much decomposed and softened, and the metal sinks into the cracks and partings of the bed-rock, and cannot be recovered without removing a foot or two of the bottom.

The quantity of mineral in the creeks of this field is not inexhaustible, and steady work year after year must eventually lead to their depletion.

It has always been recognised by those competent to form an opinion that the Heazlewood serpentine must have shed the alluvial osmiridium which is worked in the river system of the Savage. Mr. T. H. Jones, in his article in the "Mining and Engineering Review" of August, 1912, describes the western edge of the mass of the Bald Hill as the source from which it must have been derived. On seeing the locality one cannot but assent to this view.

Mr. Geo. F. Harrison, assayer at the Mt. Bischoff Extended Tin Mining Company's laboratory, informs the writer that he recovered osmiridium by assay from specimens of rock received from Purcell and Wick's claims on the Bald Hill in March last year.

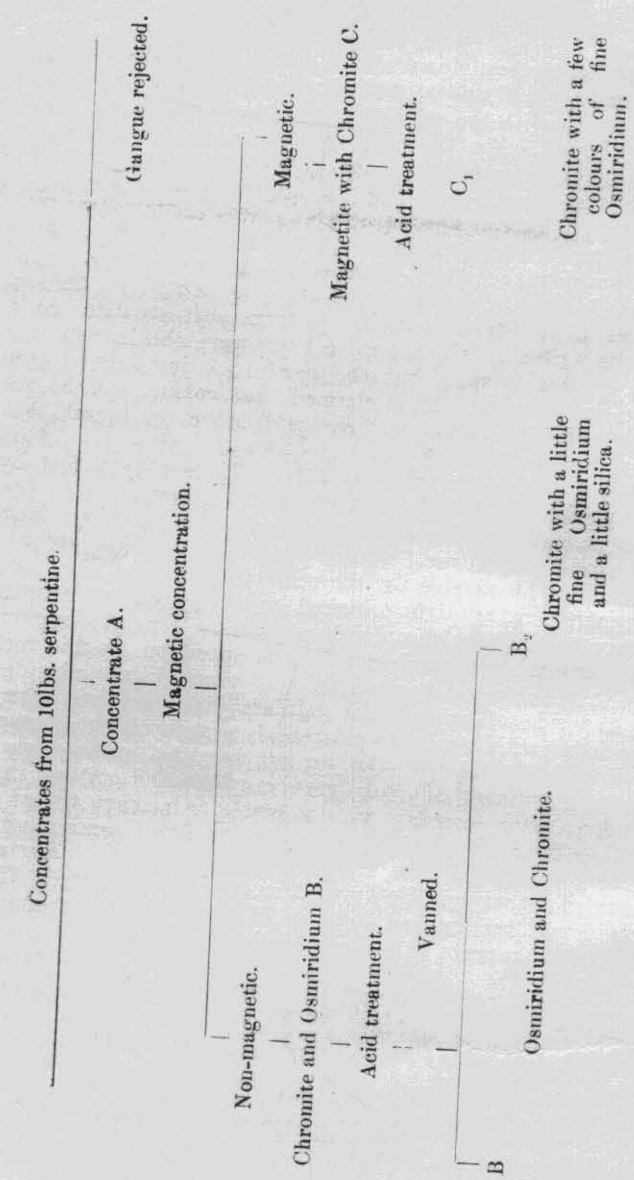
During the present year assays of samples from the western slope and the summit of the Bald Hill have revealed the presence of osmiridium in the solid stone. Serpentine rock from Caudry's section on the west fall showed in the Government laboratories an osmiridium content of 10 per cent.; while a piece brought home from Mr. Caudry's workings on the present journey yielded at the rate of about 59 oz. per ton. The writer also saw osmiridium recovered by assay in the Mt. Bischoff Extended Company's laboratory from the veined serpentine in the formation on Purcell's claim on the summit of the Bald Hill.

Various assays of rock samples from the claims taken up on the hill have been made from time to time in Zeehan and Melbourne, and have given returns of osmiridium.

(1) *Caudry's Mine.*

Last September Messrs. W. Caudry and Fenton started prospecting the upper part of McGinty's Creek. They were struck with the possibility of the mineral being found in solid rock. Mr. Caudry, by loaming up the hill north of the creek, traced osmiridium up to a line of rock coursing north-west—south-east, beyond which he could win no alluvial or detrital mineral. Along this line he eventually discovered osmiridium in the solid serpentine by crushing and washing the stone. From the first excavation which he made, Mr. Caudry states that he obtained several ounces of mineral, principally from soft steatitic rock. On the writer's visit, several colours were obtained by the dish from this spot, but the hard rock just here is too poor for dollying. It is claimed that colours can be got along this line for a few chains further south-east, but none on the upper side of it.

About a chain north-west a hole 7½ feet by 2 feet by 4 feet deep has been excavated in rock, showing first a few inches of overburden; then softened rock, passing down into solid serpentine. The rock variety, which appears to be most favourable for the mineral, is a kind of altered serpentine, rather light-coloured, soft, waxy in appearance, greasy to the touch, and intersected by dark ferruginous and serpentinous veinlets. In one specimen of this rock the writer saw a fair-sized flake of osmiridium embedded by the side of one of the veinlets just mentioned, and associated with a minute cluster of crystals either of magnetite or chromite. On unwatering the excavation a couple of dishes of rock were crushed and sifted, and yielded, after scouring with a pestle to remove the iron coating from the grains, tin-white specks of osmiridium; further treatment in the offices of the Geological Survey revealed a total yield of over 2 oz. per ton of stone. The treatment was carried out by Mr. L. L. Waterhouse, B.E., who reports on same as follows:—



"The concentrates A from the vanning of 10 lbs. of crushed serpentine were subjected to magnetic treatment and magnetite (with some chromite) removed.

"Non-magnetic residue = chromite and osmirid.um with a little serpentine = B.

"Magnetic concentrate = magnetite with a little chromite = C.

"Non-magnetic B, treated with nitro-hydrochloric acid and then vanned to separate as much chromite as possible. Concentrates from this vanning B_1 consist of osmiridium with a little chromite. Vannings B_2 are mostly chromite with a little fine osmiridium and a little silica. From B the coarser grains of osmiridium were mechanically separated and weighed ($4\frac{1}{2}$ grains). The residue carried a good deal of fine osmiridium, estimated at $\frac{1}{2}$-grain. Magnetic concentrate C digested with nitro-hydrochloric acid and magnetite dissolved. Residue C is chromite, carrying a little fine osmiridium."

Two pieces of altered serpentine rock were given to the writer by Mr. Caudry as being extremely likely to contain osmiridium. Though no surface signs of the mineral could be detected, even upon careful examination with a magnifying glass, the stone after treatment by Mr. Waterhouse gave a return equal to over 59 oz. per ton.

The mineral frequently cannot be recognised in the dish prospects until it has been cleaned by acid. Experiments indicate that besides being occasionally coated with oxide of iron, some of it is enclosed in the grains of chromite, with which mineral it is possibly intergrown, as well as being mechanically involved in it. Kemp mentions that chromite is sometimes intermingled with platinum in nuggets of the latter in such a way that sometimes one mineral and sometimes the other is the host, and that there seems to be no question that the two minerals have crystallised together.*

About 150 feet north-west from Caudry's principal excavation the surface of the rock has been uncovered and broken up for dollying. Softened rock and soft patches of clay here surround solid relicts of the stone. Two dishes washed at this point yielded several colours of osmiridium. The results obtained naturally do not possess the weight of the evidence furnished by the deeper excavation, but the clay and overburden seemed to the writer to have been derived from decomposition *in situ*.

* The Geological Relations and Distribution of Platinum and Associated Metals by F. Kemp, Bull. U.S. Geol. Survey, No. 193, 1902, p. 25.

The serpentine rock associated with these occurrences is in a more or less altered and softened condition, and shows here and there decayed whitish flakes of bronzite, having a mica-like appearance to the naked eye. The matrix rock of the osmiridium was apparently a peridotite. None of the structural features of a lode are present, but Mr. Caudry claims that by prospecting he has established the existence of a line of mineral deposition in the serpentine on his section, and that the osmiridium which he has traced to its source appears to be confined to this line of rock, though, of course, prospecting on a larger scale than he has been able to command may in the future open up other similar lines.

The distribution of metals of this group, as we are taught by both theory and experience, is (with the exception of platinum, which shows a migratory power in exceptional instances) dependent on magmatic segregation, and does not take place by deposition from solution. Any fracture-channels in the serpentine must have originated subsequently to the crystallisation of osmiridium from the magma. But no such fractures or lode-channels are visible in Caudry's section, and if it is necessary to admit the existence of a line of mineral deposition, the most rational comparison would be with short magmatic "schlieren" or differentiation streaks, which form during mass cooling, and may give a directional appearance to the ore occurrences. If miners meet with these, they very naturally term them ore shoots or pay streaks. Such "schlieren" or magmatic bands have been detected in the platinum-bearing rock of the Urals, but though they are sometimes rich in platinum, none are known which are of sufficient size to be worked profitably.

The writer understands that Mr. Caudry has extracted a good many ounces of mineral from the excavations and trials which he has made at intervals along a line of 400 feet in length. The occurrence is one of extreme interest, for the only occurrence of osmiridium in solid rock elsewhere is that reported by De Hautpick from the Korein deposit in olivine rocks in Nijni-Tagil, Russia.*

(2) *Purcell Bros.' Mine.*

On the summit of the Bald Hill are some half-dozen mineral sections which were taken up for silver-lead ore in 1892 and 1893, and one 40-acre section (1454-87M) was

* The Mining Journal. E. De Hautpick. Aug. 24, 1912, p. 851.

applied for even as far back as 1888. No mineral seems ever to have been won on these sections, but they were evidently secured with the idea of exploiting a line of gossanous, chalcedonic, and opaline outcrops trending north-east—south-west for practically the whole length of the hill. The principal lode-line appears to send off subsidiary spurs at varying angles. The main lode is several feet in width, and other veins range from 1½ foot to 2 feet. These outcrops are composed of limonite gossan intermixed with chalcedony and opaline silica, frequently quite cellular or cavernous. Serpentinous and pyritic veinlets ramify through the lode outcrops. Intersecting veins create areas over which lumps of loose gossan are scattered for some width, besides which the serpentine rock itself carries a good deal of magnetite, which adds to the ferruginous aspect of the soil. There is a free forest growth where these lode outcrops are marked, otherwise the surface of the hill is treeless.

The Purcell Bros. have opened trenches on this lode-line, both at the south end of the hill overlooking Caudry's and towards the north end.

The southernmost trench is about 250 feet above the main-road, and has been cut across a lode about 3 feet wide, with an outcrop of limonite gossan and cellular silica. The lode boundaries are sharply defined. It strikes N. 40° E., with a steep dip to the north-west. The visible metallic contents are crystals of magnetite embedded in opaline silica. This outcrop has been reported to carry osmiridium. The samples which the writer took, and which were assayed by the Government Analyst, did not yield any return of that mineral.

Further north-east, 100 feet north of Caudry's south-east corner peg, 6252-M, is another trench in decayed serpentine, cutting a lode of dense opaline silica, dark in colour, and 18 inches wide. It carries sparse disseminations of magnetite. Its strike is N. 15° W., so it must be one of the spur veins.

A few chains north of the above are a couple of trenches which have exposed a lode of opaline silica, with a little quartz and (rarely) magnetite. This lode is about 2 feet wide, and bears north-north-west.

A hundred feet further north-east is a small trench showing similar opaline silica, but evidently on a vein situate to the east of the preceding one. These trenches apparently disclose a belt of veins, some of which run east of north, and others west of north. The north-easterly line then leads one across the button-grass plain for some distance along a weak section of the lode as far as Purcell's principal trench in the timbered country. Here a trench 20 feet long by 4 feet wide and 5 feet deep has been cut across a 3-feet lode bearing about N. 36° E., with a north-west underlay. The outcrop of this lode is limonite gossan, and its gangue is flinty-looking opaline silica, which is occasionally of a cellular texture. Below the superficial gossan there are indications of the lode gangue enclosing portions of serpentine rock. The lode outcrop is bounded on the hanging-wall side by a soft and decayed bluish-green serpentine rock, which is intersected by numerous metallic veinlets, some black and magnetic, some yellowish and pyrrhotitic, others white and pyritic. The latter were at one time surmised to be osmiridium, but tests have shown that they consist of pyrite. The same veins appear also in the oxidised rock crust. Samples from the hanging-wall rock have been assayed in the Bischoff Extended laboratory by Mr. Geo. Harrison, and found to contain osmiridium. The distribution of the mineral is evidently extremely erratic, for none of the samples taken by the writer from this outcrop were found to contain osmiridium.

About 20 feet south-west from the trench a north-and-south gossan outcrop joins this lode. A few chains further north-east is another trench exposing the main lode again, which is here very siliceous, and looks rather unpromising. North of this again is an ancient trench in green-stained cellular siliceous material, which seems to represent a different lode.

No work has been done on these lodes beyond surface trenching, but the Purcell Bros. who came up here within the last year have apparently established the occurrence of osmiridium in the serpentine rock which forms the western wall of the principal lode, and further discoveries have been reported in the press since the writer was on the field. The fact that the western brow of the hill skirts the general belt and trend of the opaline and chalcedonic lodes, and that so much osmiridium has been won from the western slopes of the hill, has originated the supposition that these lodes are the main source of the metal. This, however, cannot be seriously discussed before it is shown that the mineral occurs in the lodes fairly plentifully. In the meantime, all that we know of the origin and physical properties of osmiridium is diametrically opposed to its authigenic occurrence in veins which originate from

solutions. Osmiridium is the most refractory and insoluble of known minerals, and its introduction in solution into siliceous veins is almost inconceivable.

The whole question of the origin of these veins of chalcedony and opaline silica is full of interest. It is probable that they have been formed in the rock joints as the result of solutions started in the serpentine by the expiring action of the magma. On this hypothesis, the cooling and attenuated aqueo-siliceous solutions filtered into existing joint fissures, and might possibly involve mechanically small quantities of osmiridium and other minerals during their passage. The veins of pyrrhotite which intersect the serpentine which is associated with these lodes must be of magmatic origin, and the serpentine is so intimately mixed with the siliceous and metalliferous veins that mere assay results may be misleading when one seeks the precise derivation of the osmiridium obtained. The latter may be genetically connected with the serpentine which is traversed by the veins, and not with the veins themselves. This is probably the case, as osmiridium must have separated out from the magma as one of the earliest minerals.

In support of the above view, it may be mentioned that in microscopically examining thin slices of the opaline lode material certain areas in the slide are seen to contain minute grains of magnetite disposed along structural lines, which evidently represent the survivals of the meshwork of serpentine after olivine. In Purcell's large trench the bluish-green silica-saturated rock shows in the opaline matrix crystal forms of olivine entirely replaced by magnetite which has been derived from the decomposition of the original mineral, and everywhere grains of magnetite can be observed deposited along veinlets of serpentinous matter. The abundance of this secondary magnetite accounts for the prevalent coating of the osmiridium grains with magnetic oxide and limonite.

The above is essentially all that is known as to the mode of occurrence at Purcell's at the present stage of operations. Laboratory tests have indicated the presence of a little osmiridium, and steps should be taken to follow the surface occurrences down to a moderate depth and get out parcels of stone in order to see what the working conditions are likely to be. Surface prospecting should also be prosecuted on the property, for it is almost certain that other belts of mineral-bearing rock exist on it.

(3) *Fenton's Mine (now incorporated in the Bald Hills Osmiridium Mines, No Liability).*

This is situated on the wooded range north of the Bald Hill proper, and on the continuation of the same serpentine country. This part of the field has received attention only since the beginning of the year, but since work was started on it, alluvial miners have won nearly 100 oz. of osmiridium. Some of this has been very coarse. The largest nugget was a 9 dwt. piece, which was found by the Fenton Brothers. This is now in the possession of Mr. J. D. Millen, general manager of the Mt. Bischoff Tin Mining Company, Waratah, who has kindly furnished the writer with a photograph of it, which appears as the frontispiece of this bulletin. It is a beautiful solid nugget of clustered crystals of osmiridium, showing slightly-worn surfaces. These crystals are apparently naturally welded on to one another, and the nugget no doubt existed in the country-rock in its present form, and has not resulted from the cementation of separate grains in an alluvial bed, as interstitial cementing material is entirely absent. Mr. Baptiste also found a nugget here weighing 6 dwt. 15 gr., besides some 5 dwt. pieces. Other nuggets, 5 dwt. and 7 dwt., have been obtained from Fenton's Creek. Several smaller pieces, ranging from ½-dwt. to 2 dwt., were shown to the writer, and a few small nuggets were presented to the Department by Messrs. Fenton for exhibition in the Victoria Museum, Launceston, where they have been placed. Mr. B. Osborn, of Whyte River, also presented a nice nugget weighing over 2 dwt., which is displayed in the same museum.

As only one or two specks in the Savage River district reached a weight of 1½ dwt., and 14 grains is the highest reported from the south end of the Bald Hill, the above discoveries have caused some excitement. Some of these large pieces have a value of their own as mineral specimens, but commercially they are not so valuable as isolated grains suitable for manufacturers' requirements, though it is somewhat difficult to make the sellers realise this.

On the summit of Fenton's Hill a lode is marked by a wide outcrop of gossan, associated with cellular silica of the opaline and chalcedonic varieties, and striking about N. 7° W. This can scarcely be the same lode as Purcell's, but has evidently been the result of the operation of a similar lode-forming process, as the gangue and outcrop of both are identical in character.

A long curved trench has been cut in the limonite gossan about 30 feet long by 4 feet wide and 5 feet deep, showing a wall of serpentine rock at its west end. The excavation at each end is in gossan, and the central part appears to be in altered serpentine. This serpentine is a decayed greenish variety, exactly similar to that in Purcell's trench, carries scattered specks of magnetite, and is traversed by minute veins of opaline silica and pyrite. Osmiridium is stated to have been obtained from the solid rock in this trench, and a dish of the loose gossan and detritus showed some of the mineral on the occasion of the writer's visit. This, however, possessed the form and lustre of alluvial mineral. Various surface yields have been reported along the line of outcrop. Some hundred feet lower down the hill an adit has been started with a view of cutting the lode in depth. Until this has been done, adequate data do not exist for the formation of an opinion as to the essential nature of the occurrence, though sound reasons may be advanced for distrusting these siliceous lodes as sources of osmiridium. The writer's opinion is that the country-rock rather than the lode will be found to be the host of the mineral, the veins indicating fractures filled with silica and sulphides subsequent to the segregation of the osmiridium in the cooling rock. Some good coarse mineral has been found in patches in the bank of the gully below the tunnel approach (9 oz. from one spot, and some more further down), and some also, it is said, from above the tunnel, so that it seems likely that something really good may be uncovered in the gully rock if this is persistently and systematically prospected. Such work may be regarded as a very important feature of this proposition. The mineral found in isolated patches in the gully bank has in all probability not been shed from the lode at the top of the hill, but has for the most part resulted from the disintegration of the country-rock west of the lode, and not very far from the places where it was discovered. The prospects of this part of the property may, indeed, be looked upon as highly encouraging.

Down towards the Nineteen Mile Creek Mr. McGinty has been doing well in a small alluvial basin enclosed by steep and low hill ridges. Some of the mineral which he has won is remarkably coarse; his nuggets frequently have a fragile appearance, being composed of rather loosely-aggregated crystals. This is a different habit from that of some of the solid nuggets met with higher up in Fenton's gully. The confined area produces the impression that McGinty's osmiridium has been derived from the banks of his little flat only a few yards distant from his actual workings.

Towards the mouth of Fenton's Creek Mr. Hancock is washing osmiridium from the overburden and crevices in the serpentine. This prospector informed the writer that he always regarded the proximity of decayed bronzitic peridotite rock as a favourable indication for osmiridium.

VI.—OCCURRENCES OF OSMIRIDIUM IN TASMANIA AND ELSEWHERE.

Exclusive of the Bald Hill field, osmiridium elsewhere in Tasmania has been reported only from alluvial and detrital deposits. The following are the recorded localities:—(1) Savage River; (2) Heazlewood River; (3) Whyte River near its junction with the Pieman; (4) Badger gold diggings west of the Savage River; (5) Castray River; (6) Huskisson River; (7) Wilson River; (8) Salisbury goldfield near Beaconsfield; (9) tributary of the Fourteen Mile Creek near Tyenna; (10) Boyes River, flowing into the Gordon below the Great Bend.

It has been doubtfully reported from near Lynchford and from the Clark valley, between Mts. Darwin and Sorell, but investigations have failed to confirm these; no serpentine rock is known to occur in these localities.

Outside Tasmania the following are places where its occurrence has been noted:—

New South Wales.—In sand from the Aberfoil River*; in gem sand at Bingera, at Mudgee, Bathurst, and other places.

New Zealand.—Nelson goldfields.

Japan.—In platiniferous sands of the River Yubari.

Borneo.—Alloyed and involved with platinum in gold drifts.

Brazil.—In the province of Minas Geraes in gold drifts.

West Indies.—In the Yagui River auriferous sands, San Domingo.

Colombia.—In platiniferous sands.

Oregon and California.—In beach sands and gold placers. From the Oregon inland diggings nuggets of platiniferous osmiridium have been obtained which yield a little platinum with aqua regia treatment, and then separate into flakes of osmiridium. The sands there usually contain platinum alloyed with much osmiridium, the latter increasing sometimes to 90 per cent. and upwards.†

* The Mineral Resources of New South Wales, by E. F. Pittman, 1901, p. 86.

† J. F. Kemp., *op. cit.*, p. 53.

British Columbia.—Involved with platinum in river gravels.

Russia.—In addition to the osmiridium mixed with platinum in the placers, the sands contain free osmiridium. M. E. de Hautpick reported in August, 1912,* what he called the only case of direct discovery of osmiridium in the Korein deposit in olivine rocks in Nijni-Tagil.

South Africa.—" The Chemical News," No. 107, pp. 230-2, 244-5, 253-5, mentions small quantities of osmiridium (with generally some ruthenium) as being found in the battery concentrates and sand residues in several South African mines. It is associated with gold and pyrite, but has not been recognised *in sitû* underground or in hand specimens.

Outside Russia, therefore, the occurrence in serpentine rock at the Bald Hill is the only example known, and is, moreover, the only instance *in sitû* in a quantity at all approaching what is suggestive of commercial value.

Most recorded analyses of platinum nuggets show the presence of iridium and osmiridium, and some indicate osmiridum as being directly involved with the platinum, but from the literature of the subject one gathers that except in Tasmania the occurrences of free osmiridium are unimportant. Beyond the reach of the official Russian statistics, however, an unknown quantity of osmiridium from that country comes into the market surreptitiously, so that the real statistical position is hidden in obscurity.

* The Mining Journal, Aug. 24, 1912, p. 851.

VII.—THE MINERALOGY AND METALLURGY OF OSMIRIDIUM.

The mineral was first found as an insoluble residue after the treatment of platinum ores, and was for a time regarded as a single metal; but Tennant, in 1804, discovered its binary nature, and named its two components osmium and iridium. It is essentially a native alloy of these metals in variable proportions; but with them are always bound up other metals, and the resultant varieties are numerous. Thus, ruthenium, rhodium, and platinum are associated elements, which give rise to complicated and uncertain varieties. Further, our knowledge of its composition is distinctly defective; the ill-understood varieties prevent the analytical results from being determinative. Hautpick, the Russian writer on this subject, enumerates osmite, rhodium nevianskite, ruthenium nevianskite, platinum nevianskite, sisserskite, nevianskite, and says that there are still other varieties. Copper and iron have also been detected. Exclusive of purely physical differences, this complex and variable constitution makes it impossible to value or give proper quotations for parcels of ore coming forward without analysis in each case. Buyers of Tasmanian ores have to take the parcels as they come, and trust to an average being maintained.

Hautpick gives the following **analytical table, showing the range of composition of the nevianskite** varieties:—*

	Ir	Rd	Pt	Ru	Os	Cu	Fe	Pd
Nevianskite....................	46·8 - 77·2	0·5 - 7·7	0·1 - 2·8	0 - 0·5	21 - 49·3			
Ruthenium-nevianskite.......	43·3 - 57·8	0·6 - 5·7	0 - 0·6	4·7 - 8·5	33·5 - 43·9	0 - 0·9	0 - 1·4	—
Rhodium-nevianskite.........	70·4	12·3	0·1	—	17·2	0·1 - 0·8	0·1 - 1·0	—
Platinum-nevianskite	58·2	1·8	10·1	5·9	27·3	—	—	—
						traces.	—	—

Nevianskite is that variety of osmiridium (tin-white) which contains over 40 per cent. of iridium; and sisserskite is the variety (steel-grey) in which the iridium proportion is less than 30 per cent.

Professor Kemp gives the following analyses of osmiridium:—

	Russia.	Colombia.	Russia.	Russia.	Borneo.	Australia.	Colombia.	Russia.	California.	Russia.	Russia.	Russia.
Ir	77·20	70·40	70·36	64·50	58·27	58·13	57·80	55·24	53·50	46·77	43·94	43·28
Os	21·00	17·20	23·01	29·90	38·94	33·46	35·10	27·32	43·40	49·34	48·85	40·11
Pt	1·10	·10	·41	2·80	·15	...	...	10·08	...	...	·14	·62
Rh	·50	12·30	4·72	7·50	2·64	3·04	·63	1·50	2·60	3·15	1·65	5·73
Pd	..	...	...	...	...	...	...	trace	...	...	...	...
Ru	·20	...	...	...	...	5·22	6·37	...	·50	...	4·68	8·49
Au	...	...	...	...	...	...	...	...	...	...	...	...
Fe	...	...	1·29	1·40	...	...	·10	trace	...	·74	·63	·99
Cu	trace	...	·21	·90	...	·15	·06	trace	...	...	·11	·78
Total	100·	100·	100·	100·	100·	100·	100·	100·	100·	100·	100·	100·

* **The Mining Journal, Aug. 24, 1912, p. 851.**

No analyses of Tasmanian osmiridium are available, but the mineral probably belongs to the nevianskite division. Petterd records the specific gravity of a 60-gr. specimen from the **Whyte River** as 19·5. **Dana** gives the specific gravity range as 19·3-21·12, the heavier figures belonging to sisserskite. **Hautpick** cites 22·6-22·8, which is even heavier than the determinations for osmium.

It occurs in the form of irregularly-shaped flattened **grains, or clusters of these, forming nuggets.** The heaviest nugget yet recorded from any part of the world is the 2 oz. piece found by Mr. Sweeney in the Pieman River country. The grains have a metallic lustre, are tin-white to lead-grey in colour, show sometimes a perfect cleavage, and have a tendency to be slightly brittle. Its hardness is from 6·5 to 7 on Mohs' scale.

A few words here on the two component metals of osmiridium. **Osmium* is the heaviest, most infusible,** and most insoluble of metals. The fused metal has a greyish-blue colour; its specific gravity is stated to reach nearly 22·5. Its hardness is indefinitely stated in the text-books to exceed that of glass. It fuses only in the heat of the electric arc. Its crystals are insoluble in aqua regia, but if finely powdered it becomes soluble both in fuming nitric acid and in aqua regia, and by fusion with nitrates. Care has to be taken in its extraction, for the volatile pungent acid produced during oxidation is extremely poisonous and induces blindness—temporary or permanent—and extreme irritation of the respiratory organs, as well as affecting the skin.

Messrs. E. Cahen and W. O. Wootton describe a method of extracting osmium from osmiridium, as follows:—†

"The osmiridium residues left after treatment of platinum concentrates with aqua regia are fused with zinc, and the latter removed by volatilisation in a closed vessel. The material thus reduced to a fine powder is roasted at a high temperature in a current of air, when osmium tetroxide alone distils over and is collected in dilute alkali. Ammonium sulphide is added to the solution to precipitate osmium sulphide. This is then introduced into a carbon crucible, the space between being filled with sand. A cover is luted on, and the whole heated at about 1500° for four to five hours to effect reduction to the metal.

* **From ὀσμή (smell), owing to the strong odour given off by osmic acid.**

† **The Mineralogy of the Rarer Metals, by E. Cahen and W. O. Wootton, 1912, p. 75.**

"A wet process has also been employed depending on conversion of the osmiridium into the chlorides by heating in a stream of chlorine."

J. Ohly describes another method by which "powdered osmiridium is mixed with one part of sodium chloride and exposed in a glass tube to a current of dry chlorine gas at dull redness, when the double chlorides of the two metals are formed . . ." After being "dissolved with boiling water the solution is concentrated by evaporation, acidulated with nitric acid, and distilled from a retort until the whole of the osmium has volatilised." The fumes of osmium tetroxide "are conducted into a receiver containing a solution of caustic potash, and the alkaline solution thus obtained is evaporated with an excess of ammonium chloride, which leaves on ignition of the dry residue and washing with water, metallic osmium."*

Dr. Ohly also mentions that when osmium is heated with 5 per cent. or 6 per cent. tin at bright redness it dissolves in the latter, and on treating the cooled alloy, osmium remains as a hard crystalline powder with the high specific gravity of 22·48.

The melting point of osmium is 2500° Centigrade.†

Iridium.—This is the other constituent of osmiridium, and is a brilliant greyish or silver-white metal with the lustre of shining steel or tin. It has a specific gravity of 22·42, a little less than that of osmium. Its hardness is between 6 and 7. It crystallises in the isometric system, has indistinct cleavage and hackly fracture. It is insoluble in aqua regia (nitro-hydrochloric acid) unless finely divided. A partial oxidation takes place when it is fused with sodium nitrate, and the fused substance may be dissolved in boiling aqua regia.

Cahen and Wootton give the following method of recovering it:—‡

"The iridium of commerce is recovered from the osmium-iridium alloys remaining after the attack of platinum ores by aqua regia. To obtain this very resistant metal in a form in which it is readily open to attack, it is fused with its own weight of lead and the same amount of litharge. The lead is then removed by solution in nitric acid. An alternative process is to fuse with zinc and remove this metal by volatilisation. The residue is boiled

* Analysis, Detection and Commercial value of the Rare Metals, by J. Ohly, 1907, pp. 89-90.

† Inorganic Chemistry, by I Remsen, 1907, p. 825.

‡ *Op. cit.*

with nitric acid, which brings iridium into solution, whilst osmium tetroxide volatilises. Baryta is added, and the precipitated oxide dissolved in aqua regia, and then precipitated as the double chloride by addition of ammonium chloride. On ignition, spongy iridium is obtained, with a small amount of ruthenium (removed by fusion with saltpetre) and rhodium, which may be eliminated by fusion with lead and treatment with aqua regia."

In this spongy form the metal possesses a lower specific gravity than after fusion, viz., only 15·86.* Fused iridium is white and brittle. Its melting point, as noted by different observers, varies from 1950° to 2500° Centigrade. It alloys with tin as well as zinc, and forms a fusible, acid-resisting alloy with platinum.

Some varieties of osmiridium are magnetic, but this property does not seem to be possessed by the Bald Hill mineral. Dr. Leibius† states that the gold brought to the Sydney Mint is alloyed with a sometimes not inconsiderable quantity of osmiridium. He says that at a heat at which gold fuses freely, the osmiridium sinks to the bottom of the melting pot, where it is easily separated from the gold. He describes the method (Woehler's) which he adopted for extracting pure osmium and pure iridium from the crude osmiridium recovered from the gold. It appears, however, difficult to recover iridium entirely free from osmium. Briefly, the process is as follows:—Powdered osmiridium is mixed with an equal quantity of fused salt ($NaCl$), heated in a tube in a gas furnace, and exposed to the passage over it of moist chlorine gas. The result is the formation of a double salt of chloride of sodium, with chloride of iridium, as well as a double salt of chloride of sodium with chloride of osmium. The water of the chlorine gas decomposes a great part of the chloride of osmium into osmic acid (which escapes and is collected) and into metallic osmium and HCl. The metallic osmium is again formed into chloride of osmium, and combines to a double salt. The tube contents (containing the double chlorides of iridium and osmium with sodium) are dissolved in water. Only about 30 per cent. of the osmiridium is brought into solution, and the process has to be repeated. After three operations Dr. Leibius recovered 50 per cent. in solution.

The solution is distilled with nitric acid, and the chloride of osmic acid distils over and collects in dilute ammo-

* Introduction to the Rarer Elements by P. E. Browning, 1904, p. 133.

† Trans. Phil. Soc. of New South Wales, 1864 (1862-65, pp. 210-215.)

nia. The hot residue is poured into a strong solution of sal ammoniac, when the greater part of the iridium falls down as a double salt of chloride of ammonium, with chloride of iridium or irid-salmiak.

The liquid is filtered off and evaporated with soda, heated in an earthen crucible, and then boiled out with water, leaving oxide of iridium behind as a blackish powder, which can be dried and reduced to iridium by hydrogen gas.

The osmium collected as described above is obtained partly as osmic acid and partly as chloride and bichloride of osmium. It is dissolved in weak ammonia, and the yellow solution is evaporated till a compound of ammonia-sesquioxide of osmium falls down as a black powder. On heating this it decomposes with the evolution of nitrogen and aqueous vapours, and the osmium is reduced violently to the metallic state. Addition of one-third sal ammoniac reduces the violence of this decomposition.

Ohly gives a method of detecting the presence of osmiridium as follows:—*

"To distinguish iridium, mix the mineral supposed to contain that metal intimately with sodium chloride, place the mixture in a porcelain boat, heat the mass in a current of chlorine, and dissolve the double chloride of iridium remaining in the boat in water. Iridium thus treated yields a black-brown solution, rhodium a rose-red, and ruthenium an orange-yellow liquid. Evaporate the solution on the water-bath, place it in a porcelain boat, and reduce the residue to the metallic state by ignition in a current of hydrogen. It will be seen that the presence of both iridium and osmium can be traced simultaneously by the method described."

For examining sands containing platinum or osm ridium Lunge recommends the following as a very suitable method:—

"The crushed material is fluxed in a pot with red-lead, &c., in order to obtain a lead button. The lead button is cupelled, and the resulting bead rolled out and boiled in dilute sulphuric acid, the acid being gradually allowed to get stronger. The residue is washed, boiled in nitric acid, and again washed. The two resulting solutions contain the silver. The residue is then dissolved in aqua regia. Osmiridium remains, together with a trace of silver chloride and lead sulphate; the silver chloride may be dis-

* Analysis, &c., of the Rare Metals, by J. Ohl., 1907, p 100.

solved in ammonia, and the lead sulphate in ammonium acetate solution. The osmiridium is then washed, weighed, and further examined if necessary. The aqua regia solution contains platinum and gold; platinum may be precipitated by ammonium chloride and gold by ferrous sulphate."*

In examining the serpentine rock in the field for osmiridium, the sample must be dried, crushed, sieved, and panned. The metallic concentrates will then be found to consist principally of magnetite and chromite, and will contain any osmiridium that may be present in the sample. Most of the magnetite can be removed by means of a magnet, and the remainder by dissolving in hydrochloric acid. The acid treatment will remove the coating of iron oxide which covers the grains of osmiridium and prevents their recognition. Care must be taken to reduce the chromite to a fine powder, so as to set free any osmiridium that it may contain. The heavy bright grains remaining will be osmiridium insoluble in all acids and in aqua regia.

* Technical Methods of Chemical Analysis by Geo. Lunge, 1681, vol II. part 1, p. 147.

VIII.—PLATINUM IN TASMANIA.

It is singular that no undoubted platinum has yet been found with the Tasmanian osmiridium. Its occurrence has been reported from time to time, but no authoritative identification of the metal has been published. In Petterd's "Catalogue of the Minerals of Tasmania" it is referred to as follows:—

"This metal has been reported to occur at St. Paul's River, at the Pieman goldfields, as minute flakes in auriferous wash at Salisbury (near Beaconsfield), and at Wilson's River, which is a tributary of the Pieman. All the identifications are doubtful and need confirmation."

Many analyses of platinum from other countries show an osmiridium content; *e.g.*, in Borneo, Peru, Colombia, British Columbia, Oregon, and Russia; and the latter mineral is generally present as an associated constituent in platinum-bearing gravels. The two metals or minerals being so intimately and generally associated, it is somewhat surprising that free platinum has not been found at the Heazlewood.

Mr. T. Purcell presented to the writer a few grains of a metal having the appearance of platinum obtained from the north end of the Bald Hill, and a larger speck (said to weigh 14 grains) is in the possession of Mr. Hancock in the same locality. The shining appearance and slightly-bluish tint of the specimens suggested that they were not osmiridium, and the inference was that they are platinum. However, on examination they were found to split in planes of perfect cleavage, did not dissolve in aqua regia (except possibly very slightly, as shown by a little roughness of surface after the acid treatment), and possessed a remarkable hardness, being scratched only by corundum. This is a hardness exceeding that of platinum and platiniridium. It may be surmised that the mineral is some alloy of iridium and osmium, in which, perhaps, platinum is very slightly represented. It has a faint lead-grey tinge somewhat similar to that of molybdenite or polished pewter. Nearest to it in general appearance is the "white metal" in domestic use.

IX.—COMMERCIAL USES OF OSMIRIDIUM.

Each of the two metals which compose osmiridium has commercial applications, and the mineral itself is also employed in the arts without dissociation of its metals.

The most important use for the mineral hitherto has been for tipping the points of gold fountain pens, for surgical needles, watch pivots, compass bearings, &c. A further use is being developed for hardening platinum, and this is likely to absorb increasing quantities of the mineral. A good deal of ignorance exists as to what new or increased use underlies the recent augmented demand for the mineral, and it is not known here to what use the whole of the increased supplies is being put. For fountain pen purposes suitably shaped and sized grains have to be selected. These must not be too small, and must not be liable to flake off during the process of working. The latter tendency is due to the perfect cleavage which the mineral possesses. Many of the grains are too small for use, and others break readily owing to their laminated structure. In consequence of these drawbacks not more than from 10 to 20 per cent. of the mineral sold is fit to be used direct for pen tips. As an ounce usually contains from 3000 to 5000 small grains, the world's known output of osmiridium may be calculated as being sufficient for half a million to three-quarters of a million pens annually. In mounting pens the mineral is soldered to the point with silver solder, then split by a rotating metal disc charged with diamond dust, and ground down to the desired shape for the nib. For this purpose the roundish grains are preferable to the flat platy pieces, as the latter are more likely to split off in plates parallel with the cleavage. The quantity named above is insufficient for the requirements of the pen industry, and the deficient supply is perhaps responsible for inferior alloys in the cheaper make of pen; or, on the other hand, the deficiency may be met by additional output, which does not come into the statistics. The writer has gone closely into the question of the total number of fountain pens turned out annually, and a rough estimate is that England and America manufacture upwards of one and a half million yearly. Taking the Continental makes into account, it seems certain that over two million pens are produced each year.* The conditions laid down by British firms in selecting osmiridium from vendors' parcels are that the grains must not be too small and not

* The writer desires to acknowledge assistance received from Mr. Selwyn Cox, Launceston, in arriving at these figures.

flaky. Cheap grades can be utilised by fusing the mineral with platinum, thus producing an amalgam which can be chipped and ground easily and makes a smooth pen. Such pens have not the life of pens tipped with native osmiridium. It is understood that most of the osmiridium dust is used for hardening platinum, which is in strong demand for crucibles, standard weights and measures, &c.

Pure iridium is not often used in the arts, except for surgical needles and jewellers' drills, being difficult to work, but, alloyed with platinum to the extent of from 10 per cent. to 20 per cent., a hard substance is obtained, which is acid-resisting, difficultly fusible, and unchanged by exposure to the air. This alloy is malleable so long as it contains only a moderate percentage of iridium; over a certain proportion of the metal (say, upwards of 10 or 12 per cent.) makes the alloy extremely hard. With high percentages it resists aqua regia.

Iridium itself has also been used in making a hard alloy for pen points. The addition of phosphorus when iridium is heated to excess in the crucible renders it fluid. The phosphor-iridium is said to be harder than osmiridium and to alloy in all proportions with platinum, silver, nickel, and iron. It is reported to be of use as an anti-friction covering.

Iridium oxide (or, as it is called, iridium black) is employed as a pigment for china.

The annual output of pure iridium is supposed to be about 5000 oz.

No information is obtainable as to whether osmium is separated from Tasmanian osmiridium, but it is improbable. Osmium has a limited technical use in histology and microscopy for hardening and colouring tissues. It was, despite the difficulties and even dangers attending its extraction, at one time in demand for the osmium incandescent lamp, which has, however, gone out of use, owing to the introduction of the tungsten filament. The osmium filament was too friable and fragile for general domestic use, and the lamp could only be used in a vertical position.

The Queensland Government "Mining Journal," Oct. 15, 1913, states that a new, hard alloy of platinum has been produced by Dr. Fritz Zimmerman, of Newark, New Jersey, by the addition of osmium. It is said that this alloy contains from ½ per cent. to 10 per cent. of osmium, and has physical and electrical properties fully equal to the platinum alloy containing a much higher percentage of iridium.

X.—THE OSMIRIDIUM MARKET AND STATISTICS.

There is perhaps no other mineral, the statistics of which are so obscure. From the published accounts it would appear as if no country outside Tasmania is producing native osmiridium in commercial quantities. The Russian output has practically ceased—at any rate, as far as official statistics are concerned—though some is said to be produced and disposed of secretly. M. de Hautpick quotes the registered output in Russia as follows:—In 1902, 143 oz.; 1903, 143 oz.; 1904, 153 oz.; 1905, 106 oz.; 1906, 45 oz.; 1907, 69 oz.; 1908, 54 oz.; 1909, 56 oz.; 1910, 52 oz.; 1911, 4½ oz. But in addition to this there is also a certain quantity which is obtained from the treatment of platinum residues, and of which no records exist. This author states that such recoveries form the larger proportion of the actual Russian output.

Lunge mentions that according to Keri, native platinum (washed platinum) contains on an average 80 to 86 per cent. of platinum, 1 to 8 per cent. of osmiridium, 0·25 to 2 per cent. of palladium, 0·4 to 3 per cent. of rhodium and ruthenium, 5 to 13 per cent. of iron and copper and 1 to 4 per cent. of sand. In the ore from the Urals the content of iridium, rhodium and palladium together is usually 4 to 5 per cent., and the residue, insoluble in aqua regia, and consisting chiefly of osmiridium is about 8 per cent.

Prior to 1911 the Tasmanian output was insignificant, but with the hardening market rates, more men flocked to the fields, and official registration was started. The statistics can, however, only be obtained in an indirect way, namely by procuring from the buyers statements of quantities purchased.

In 1911 the output was returned as 272¾ oz., and in 1912, 778¾ oz. The quantity won is largely regulated by the nature of the seasons, as the wash in the Savage River can be worked only when the water is low. During winter and wet months work is restricted to the tributary creeks. It should be mentioned that a small proportion of the above output has been derived from the valleys of the Huskisson and Wilson Rivers, north of the Pieman.

The increasing demand for platinum and iridium has had its effect on the price of osmiridium. As the bulk of the world's iridium is derived from platinum ores, any causes affecting the production of platinum or the refining of crude platinum will also affect the iridium market.

The platinum market is in the hands of a French company, the Compagnie Universelle du Platin, which after amalgamating with Belgian companies operating in the Urals now forms a financial group controlling the major part of the world's output of platinum ores. It has recently come to an understanding with the Russian platinum group controlled by the Demidoff heirs, and is in a very strong position, enabling it to fix the official price of platinum in Paris. A bill has been laid before the Russian Duma prohibiting the export of crude platinum, and if this becomes law the Paris company will erect its own refineries in Russia and market refined platinum. The latest information is to the effect that some time will elapse before the measure is finally decided upon, and meantime the platinum market remains as before.

The local price at present offering for osmiridium on the field is £10 17s. 6d. per oz. Last year when the price realised locally was £7 per oz. reports reached the miners that London and American quotations were much higher than this. The miners were afraid that they were not receiving full value for their produce, consequently the Secretary for Mines communicated with the Agent-General for Tasmania in London (Sir John McCall), who instituted inquiries and found that the local prices corresponded fairly well with the rates paid by European firms for raw osmiridium, but that selected grains of a size and shape suitable for fountain pens commanded a price £4 per oz. higher than the ungraded article. It appears that definite prices for the mineral can be quoted only after the examination and analysis of each parcel.

According to this year's price-lists buyers of fused iridium offer £16 to £17 per oz. The price, however, varies greatly with the quantity offered.

It follows that if iridium derived from the working up of platinum residues comes forward in excess, the values obtainable for osmiridium are adversely affected. There is this to say, however, that the supplies of platinum ore are increasing at a less rate than that of the commercial demand for the iridium-hardened metal, and as long as this is the case, market prices ought to firm. On the other hand, it is notorious that a good deal of this demand is governed by the fashions of the day. At present the fashion in jewellery is to have articles mounted in hardened platinum, but no one can say how long this taste will last. The increase in the Tasmanian osmiridium output is certainly calculated to have some steadying effect on rates, and it is difficult to say beforehand how far these will fall when buyers start to unload their stocks. A disquieting paragraph appeared recently in the Australian mining press to the effect that a severe drop in prices is expected. This is a little enigmatic, but it is understood that osmiridium in some quantity is coming forward from Russia not accounted for in the official returns.

XI.—DIAMONDS.

The peridotite rock of the Bald Hill possesses additional interest as being the probable source of the few small diamonds which have been found from time to time in the neighbourhood of Mt. Donaldson, near Corinna, in gold-bearing wash.

In 1894, L. Harvey, prospector of the New Donaldson Sluicing Company, found a small diamond in Harvey's Creek, which heads in the Donaldson Range and falls into the Savage River; and another in Sunday Creek on the west side of Mt. Donaldson, flowing also into the Savage. Lawson found some also in Sunday Creek, and another has been recorded from Middleton's Creek, which flows into the Savage River north of Corinna. The respected prospector, Mr. T. Batty, found one in Harvey's Creek in 1906. Mr. W. F. Petterd, in his "Catalogue of the Minerals of Tasmania," mentions 16, or at the most, 18, stones as authenticated. These gems were mostly octahedra, about one-eighth of a carat in weight, one reaching one-third of a carat. They have a slight yellow tinge at the apices.

These have all been found in the district round the Donaldson Range between the Savage and Donaldson Rivers. The range consists of slates, sandstone, and conglomerate of Pre-Silurian age, and no serpentine rock is known in the neighbourhood. Between the Rio Tinto Mine and Specimen Reef serpentine is said to exist on Serpentine Hill, but the main exposure of peridotite rock, from which these diamonds were probably derived, is the Bald Hill Range. A parcel of gem sand from near the Hellyer River was sent to England by the Van Diemen's Land Company many years ago, and it is said that a small diamond was detected in it; if so, it most likely came from the Bald Hill massif. Osmiridium is found associated with gold in some of the creeks round Mt. Donaldson, and unless some yet undiscovered serpentine exists there, it seems likely that the creeks are dissecting ancient gravels, to which the Bald Hill peridotites contributed. It is not probable, however, that many stones will come to light on the osmiridium field itself; the chances are greater lower down the Savage. Whatever finds eventuate will certainly be casual ones. Prospecting for the gems would be an almost hopeless task. It is sufficient for the present merely to draw the attention of those who are working in this region and recommend that a look-out be kept for diamonds while sluicing.

XII.—CONCLUSION.

The large quantity of osmiridium now being placed by Tasmania on the world's market, and the unique discovery of its occurrence in its parent rock in appreciable quantities, are facts which are bound to compel notice by all who are interested in this group of metals. The questions which present themselves insistently are:—How will this large output affect the market? How long are the alluvial fields likely to last? What likelihood is there that stone-mining will be a commercial success?

The available iridium in the markets of the world depends largely on the output of iridium-bearing platinum ores, and, accordingly, it follows that the osmiridium now being produced by Tasmania has to compete with the increased platinum output which is now under way in Russia, Colombia, and the United States. Russia heads the producing list with an annual output of about a quarter of a million ounces; and the alluvial fields now being worked there are considered good for another 20 or 30 years, after which there are still extensive privately-owned areas which are at present unworked. However, as mentioned in this bulletin, the demand for platinum goods, and especially for hard platinum, is on the increase, and the supplies do not overtake it. This implies a continuance of iridium production. But the iridium and osmiridium market is such a close ring that it is impossible for those outside the purchasing groups to form any true idea of its condition and prospects.

The Savage River alluvial deposits are likely at the present rate of exploitation to last as long as the present Russian fields, but the Nineteen Mile alluvial will be exhausted earlier, unless new areas are found higher up the creek. The country north of the existing workings will certainly be explored in the immediate future, seeing that the serpentinised rock continues further north. Little is known of the country in that direction, and it may be that fresh patches of metal-bearing ground will be discovered by future prospecting.

As for stone-mining for this mineral, the enterprise is so absolutely new that the scientific investigator will take a more or less expectant attitude. Sufficient work has not yet been done to furnish the data necessary for forming a proper opinion of the nature and extent of the deposits. All that is strictly known at present is that osmiridium exists in the serpentine rock, and that the latter has been trenched upon at spots where sampling and assay results indicate that the percentage of mineral may be sufficiently high to be payable. The dimensions of the deposits will have to be established by future work. Such concentrations of mineral in the rock are likely to be met with at more than one place on the western slopes of the Bald Hill Range. These slopes have undoubtedly shed most of the alluvial worked in the creeks and in the Savage River. Local opinion, however, on the part of some of the claim-holders is strongly in favour of the view that the bulk of the alluvial mineral has been derived from lodes situate on the summit of the Bald Hill. Certainly osmiridium is found in the zone of veined serpentine through which run certain opaline and chalcedonic lodes, but in the writer's opinion these lodes are unrelated occurrences, coursing along lines of weakened rock in which osmiridium existed prior to lode-formation. Moreover, the mineral is not restricted to these lines. As osmiridium was one of the very earliest minerals to form in the cooling magma, its prime and principal locus might be expected to be in the rock itself, and not in the veins which intersect the latter.

The lessees have now a great opportunity of demonstrating the payable nature of the lodes. They are embarking on a new and a somewhat uncertain venture, and deserve all possible encouragement. Some apprehension has been felt lest their operations should displace the alluvial miners, the prior possessors of the field. But so long as the creeks are reserved strictly for the alluvial miners, and the lessees are restricted to the high land, no injustice will be done, and the rights of both parties will be conserved.

More important than the lodes are the indications given by the small rich patches of detrital or residual terrace ground met with on the hill slopes here and there, pointing to the existence of yet undiscovered spots in the solid rock where concentrations of mineral will be found. The systematic prospecting which will now be undertaken by the leaseholders may, it is to be hoped, result in locating these spots. There is in this class of mining little to guide one beyond similarity of rock-types, and the experienced prospector's shrewdness and ability to apreciate the nature of country. The prospecting going on here will also stimulate prospecting for the mineral in serpentine areas in other parts of the State. In this connection it

may be mentioned that where osmiridium exists at all, the extent of the mass of serpentine is in some measure an indication of the extensiveness or otherwise of mineral deposition. Osmiridium has developed towards the margin of the mass. Hence, in looking for osmiridium elsewhere in Tasmania, it is well to bear in mind that the probability is that the smaller the serpentine area, the less mineral will be found; the larger the area, the more important the associated deposits.

The writer desires to thank Mr. J. D. Millen, Waratah, for much assistance on the present journey, and, *inter alia*, for the photograph (executed by Mr. J. H. Robinson) of the osmiridium nugget appearing as frontispiece to the present bulletin. Acknowledgments are also due to Mr. T. H. Jones for valuable information and guidance on the field; and likewise to Mr. S. C. Coundon.

W. H. TWELVETREES,
Government Geologist.

Launceston, 24th November, 1913.

ADDENDUM.

IMPERIAL INSTITUTE REPORT ON THE EXAMINATION OF OSMIRIDIUM FROM TASMANIA, APRIL 3RD, 1914.

(Received through Sir John McCall, Agent-General for Tasmania.)

Results of examination of half an ounce of Osmiridium grains.

1. *Mineralogical.*—The sample consisted of loose metallic grains varying in colour from tin white to yellowish grey. Half of the grains averaged about 1mm. in diameter, and the remainder about ½mm.

2. *Chemical.*—

	Per cent.
Platinum........................Pt	0.37
Ruthenium........................Ru	8.19
Palladium........................Pd	0.21
Gold ....Au	0.04
Iron........................Fe	0.30
Copper........................Cu	trace
Iridium........................Ir and Rhodium........................Rh	33.80
Osmium (by difference)........Os	57.09
	100.00

3. *Commercial Valuation and Remarks.*—The above analysis indicates that the sample consists of iridosmium (sisserskite) in which the amount of osmium present is considerably in excess of the iridium, the reverse being usually the case in the analysis of iridosmium from other sources already on record.

It does not appear likely that this Tasmanian iridosmium can be applied to any purposes other than those for which iridosmium is already used.

B56780

EXPLANATION OF PHOTOMICROGRAPHS.

Fig. 1.—Bronzitite from Bald Hill, near 18-mile. Rock composed exclusively of orthorhombic pyroxene. Crossed nicols × 19.

Fig. 2.—Olivine in Harzburgite Rock, near 19-mile hut, Bald Hill. The slide shows crystals of olivine dissected by veins of serpentine, and bounded by secondary magnetite, which has separated out from the decomposed mineral. This illustrates the derivation of much of the magnetite which is present in the serpentine rock. Crossed nicols × 19.

IGNEOUS ROCKS.

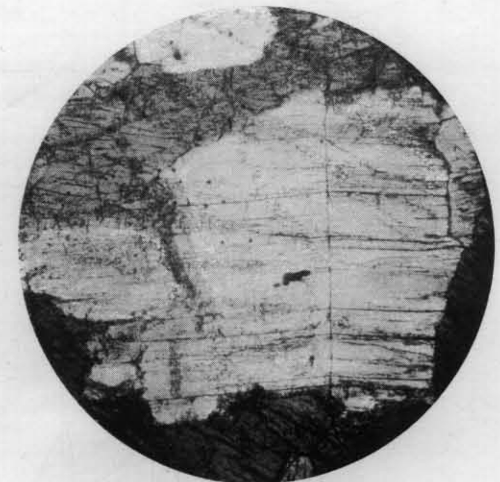
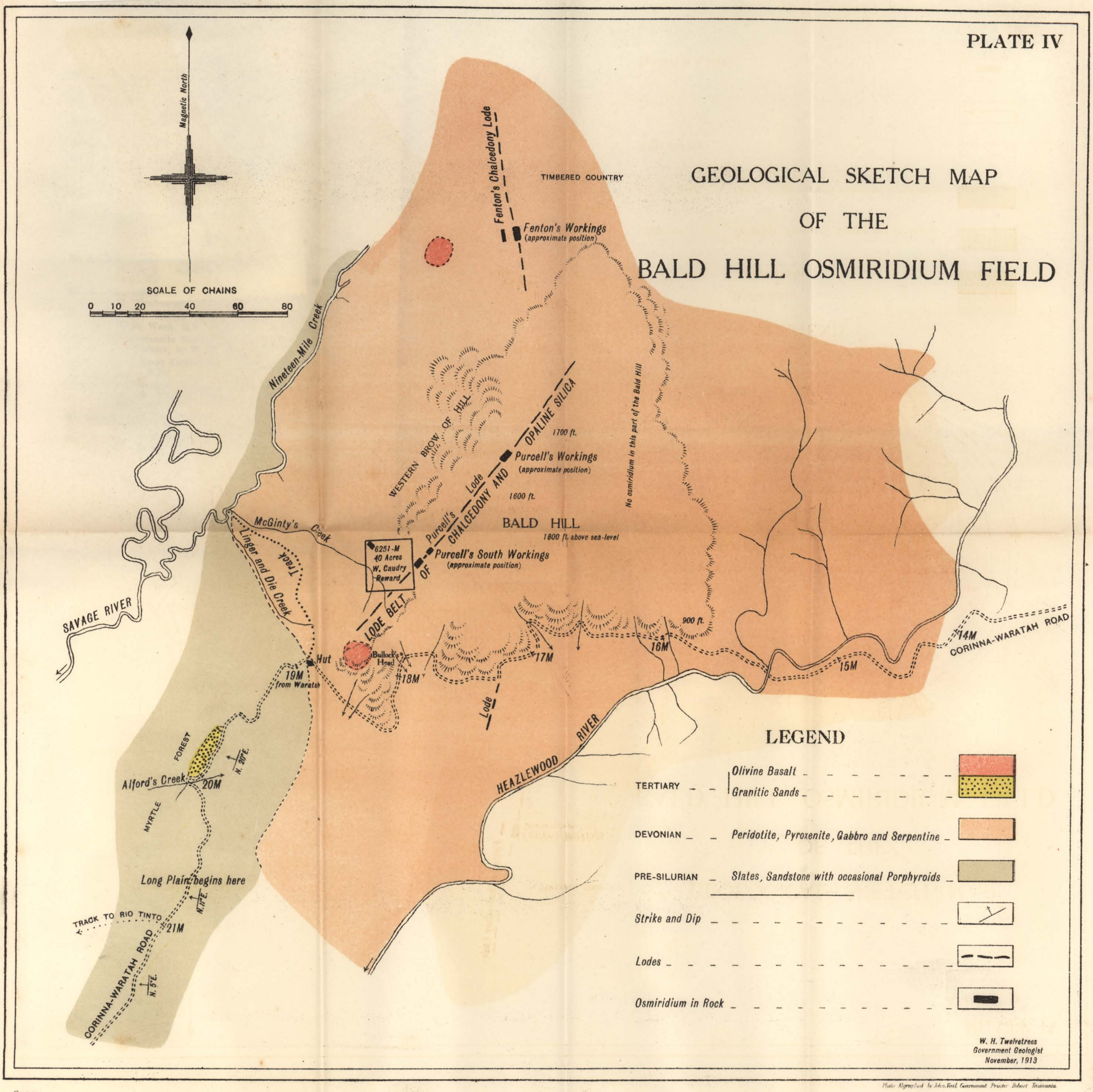


Fig. 1.

Fig. 2.

BALD HILL.

5 cm



B 53520

Photo Algraphed by John Vail Government Printer Hobart Tasmania