on rocks which had been collected during the year in the Yilgarn Goldfield. Mr. Armstrong was also engaged for a short time assisting with the card indexing of some of the publications of the Survey.

HEAD OFFICE.

Miss B. M. Bowley, B.Sc., Technical Assistant.—In addition to attending to enquiries from the general public and the ordinary routine work of the office, Miss Bowley assisted in the preparation of the Geological Survey Exhibit at the Western Australian Mining Exhibition held at Government House in October. The reorganisation of the collection in the Geological Museum has been continued, and is now nearing completion.

All technical records have been kept up-to-date, and current literature on Australian geology has been catalogued, and when time permitted, back numbers have also been cross indexed.

Reports following on the field work of the staff are attached except where such were made for purely departmental purposes.

In conclusion, I take this opportunity to express my appreciation of the work and loyal support of each member of the staff during the past year.

F. G. FORMAN,
Government Geologist.

THE ORA BANDA AMALGAMATED GOLD MINE, GRANT'S PATCH, BROAD ARROW GOLDFIELD.

(F. G. Forman, B.Sc.)

The principal leases of the Ora Banda Amalgamated Gold Mine are G.M.L.'s 1962W (Nicholson's), 1970W (Stevenson's), 1967W (Mackenzie's), and 1966W (Hall's).

Country Rock.—The country rock is an epidotized and zoisitized porphyritic dolerite, consisting of large (up to half an inch diameter) phenocrysts of basic felspar in a fine grained groundmass of grey or greenish colour. In certain areas the phenocrysts are not so large and are of a dark colour, so that the rock in the hand specimen appears to be a fine grained grey or greenish rock of even grain size. Under the microscope the two types are seen to be of essentially the same composition. The coarsely porphyritic rock is known locally as "Native Cat rock" or "Cat rock" because of its striking spotted appearance.

The porphyrite is generally massive and coarsely jointed, except in the vicinity of the shear zones which carry the ore-bodies and along certain fault zones of post-gold age, which cause breaks in the continuity of the lodes. The shearing in these cases has been intense and the porphyrite has been converted into a sheeted rock or schist.

Rock weathering and Secondary Enrichment of Gold.—The water level varies slightly in depth in different parts of the workings, from about 150 to 170 feet below ground level. The bottom of the zone of oxidation does not everywhere agree with the water level. This has been noticed in previous examinations of the Ora Banda district by A. M. Montgomery and J. T. Jutson, and is referred to by the latter in Geological Survey of Western Australia Bulletin 54, on the Mining Geology of Ora Banda.

The zone of oxidation and consequent rock alteration extends some distance below water level, suggesting that there has been a change in water level in the district during recent geological time. Examination of the mine workings shows clear evidence of secondary gold enrichment in all the upper levels. It is sometimes in evidence below present water level, secondary gold having been observed in the No. 2 east winze on Nicholson's lease at a vertical depth of about 230 feet. On the No. 3 levels (vertical depth 260 feet) in Nicholson's and Hall's leases, with the exception of a little staining by iron oxides in the quartz in the No. 2 east lode drive, no sign of secondary alteration is visible, and it appears that the conditions on these two levels should be representative of the sulphide zone. The values obtained at this depth should therefore be representative of those to be obtained with deeper development.

THE ORE-BODIES.

General Statement.—The ore-bodies are of the lode type, and consist of quartz veins and stringers in narrow shear zones in the porphyrite. There are two sets of shears with a marked difference in strike; one set striking south of east (105°-117°) and the other north of east (70°-77°). The most frequent shearing is that with a strike of from 105° to 117°, and it is in these shears that Nicholson's east lode and its extension through Stevenson's lease, Mackenzie's east lode, and Hall's lode, are located. Nicholson's west lode and Mackenzie's west lode lie in the other set of shears striking at 70° to 77°. An important cross shear at the western end of Hall's lode departs from either of these two directions, having a strike of 140°. The intersection of the shears mentioned above is considered to have governed the location and pitch of the various ore shoots at present developed. The lodes are frequently displaced by post-gold faults, the lode having been displaced to the left when followed along the strike. This type of faulting is particularly noticeable along Nicholson's west lode where the displacements have been greater and more frequent than elsewhere, but has affected all the lodes to some extent and should be borne in mind during lateral development when an ore-body is found to be cut off.

Nicholson's Lease 1962W.—On this lease two lodes are being worked, an east lode with an average strike of about 117° and an almost vertical dip varying in direction from north to south, and a west lode with an average strike of 70° and a dip to the north of 54°. The intersection of the two lodes is plainly marked by the sudden bend in the drives and is obvious from an inspection of the plan. The intersection pitches to the west and at the No. 3 level (V.D. 260 ft.) is almost opposite the main shaft.

The East Lode.—The east lode lies in a strong shear zone in which there are both horizontal and vertical components of movement. That the west side of the shear has moved eastwards relatively to the east side is indicated by the direction of fracture cleavage planes in the shear zone, which run diagonally across it. This is illustrated in fig. 1 where the direction of movement is indicated by arrows. That the shearing movement also had a vertical component is shown by the flutings with a westerly pitch, which are frequently visible on the major shear planes, and the irregularity of strike

and dip of the shear zone which would require both horizontal and vertical components of movement in order to allow them to be preserved.

The gold values occur in shoots or patches of irregular shape where the quartz veins or stringers are widest, and probably coincide with the more shattered and porous zones of the shear. One shoot is invariably connected to the next by a thin stringer or vein of quartz which lies along the main shear plane, and is important as an indicator in development work.

The western end of the east lode is its intersection with the adjoining west lode, the junction pitching northwards at about 50°. The pitch varies, however, from this average figure because of the frequent change in direction of dip of the east lode and because of the compound nature (a series of flat dipping shears with steep dipping breaks) of the west lode.

Taking the eastern end of the stopes as an indication of the eastern limit of ore of millable grade, it is found that the eastern end of the shoot pitches westwards, parallel to the intersection with the west lode, giving a horizontal shoot length of about 160 feet.

The east drive at the No. 3 level beyond the limits of the stoping has revealed low grade ore, and it is considered that further payable shoots might be exposed by further driving.

The West Lode.—The west lode shear has an average strike of 70° and dips to the north at 54°. At irregular intervals the main shear is intersected by a series of minor shears or faults of pre-gold age, which have caused a series of vertical displacements in the lode. These faults have an almost vertical dip varying from north to south. Their strike also varies; one, exposed in the No. 2 west winze 45 feet below the No. 2 level, strikes at 105°, while a second, exposed in the No. 3 level main west drive, strikes at 72°. It will be noticed that these two strikes approximate to those observed in the east and west lode shears themselves. The shears were probably formed by the same forces which produced the major lode shears, and they are therefore probably best considered as minor shears belonging to the same structural pattern.

The flat shears carry consistent gold values and constitute the west lode, while the steep minor shears or faults carry only spasmodic patches of ore. In the case of both the flat and steep series of shears the individual ore shoots are connected by a thin quartz vein (the indicator) which must be followed in development work.

Fig. 2 is a cross section of the west lode between the No. 2 and No. 3 level in the vicinity of the No. 2 west winze, and illustrates the structural features of the west lode shear pattern.

The breaking up of the west lode into a number of sections by the steep shears or faults mentioned above introduces a difficulty in development at depth, and this is illustrated by the west drive at the No. 3 level. This drive follows one of the faults which displace the lode, and it has been necessary in order to work the ore lying in the position B of fig. 2 to put in an intermediate drive above the No. 3 level. The west lode at depth should be found at an unknown depth below the No. 3 level and on the north side of the steep shear zone. The amount of displacement being unknown, it is clear that by sinking the shaft an arbitary depth of say, 100 feet, and cross-cutting to the lode, it is uncertain as to how much ore would be made available above that level. It is therefore suggested that the best method of exploration in depth below the No. 3 level is to sink a pilot winze to locate the top of the next section of the west lode and to determine its vertical extent. A suitable depth for the next level can then be decided on before deepening the main shaft.

The eastern limit of the west lode is marked by its intersection with the east lode. The extent of the present workings is insufficient to enable the pitch of the western end of the lode to be determined, but the westerly pitch of all the structural features in the lease suggests that the pitch of the lode should also be to the west. As the junction of the east lode and the west lode at the No. 3 level is only about fifteen feet east of the main cross-cut, it is therefore reasonable to suppose that the length of ore likely to be opened up by the west drive at this level should be equivalent to the whole length of the west lode as exposed at the Nos. 1 and 2 levels. The workable portion of the lode, however, will be some distance above the level of the drive as shown at B in fig. 2.

Surface workings on the west lode, well to the west of the main shaft workings, indicate that values might be found at depth beyond the present limits of the drives. Exploration in this direction appears justified, particularly as the condition of some of the shallow early workings indicates that the then owners did not fully understand the faulting system which repeatedly displaces the lode.

Stevenson's Lease 1970W.—Small rich bulges of quartz are reported to have been cut in shallow drives connected to Nos. 2, 3 and 4 shafts on this lease. These workings were examined, and judging by the position and direction of the drives, together with the appearance of the shears exposed in them, it is considered that they are all on the same shear, and that this is an easterly extension of the east lode shear in Nicholson's lease.

There is a considerable length on this shear still unexplored, lying between the drives from Nos. 2, 3 and 4 shafts, and between the No. 3 shaft drive and the eastern faces of the east lode drives in Nicholson's lease. This ground could be prospected cheaply by extensions from the existing workings.

In the end of the north cross-cut from the No. 5 shaft a narrow shear dipping to the north at about 50° is exposed, and a sample of quartz taken from this position is reported to have given a high assay result. It is considered that this shear is possibly an easterly extension of Nicholson's west lode shear. The ground between this point and the main workings on Nicholson's lease does not appear to have been prospected. A line drawn from the end of the cross-cut from No. 5 shaft on the average bearing of Nicholson's west lode, passes north of the known position of the lode in Nicholson's lease. There is no available evidence to show whether Nicholson's west lode shear is of earlier age than the east lode shear, but if such be the case, then from the known direction of movement on the east lode shear (shown in fig. 1), the west lode should be displaced to the position indicated by the line from the No. 5 shaft cross-cut.

No. 1 shaft and the workings from it were not examined, but only occasional low values are reported from the drive which is said to be on a southerly dipping shear. It is difficult to correlate these workings with any known lode in the vicinity.

Figures to Accompany Report
ON
ORA BANDA AMALGAMATED C. M.

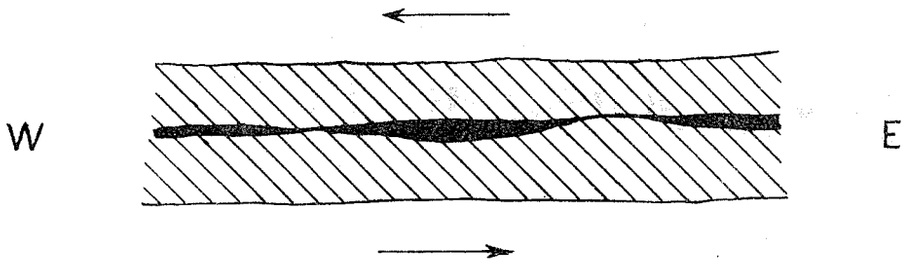

FIGURE 1

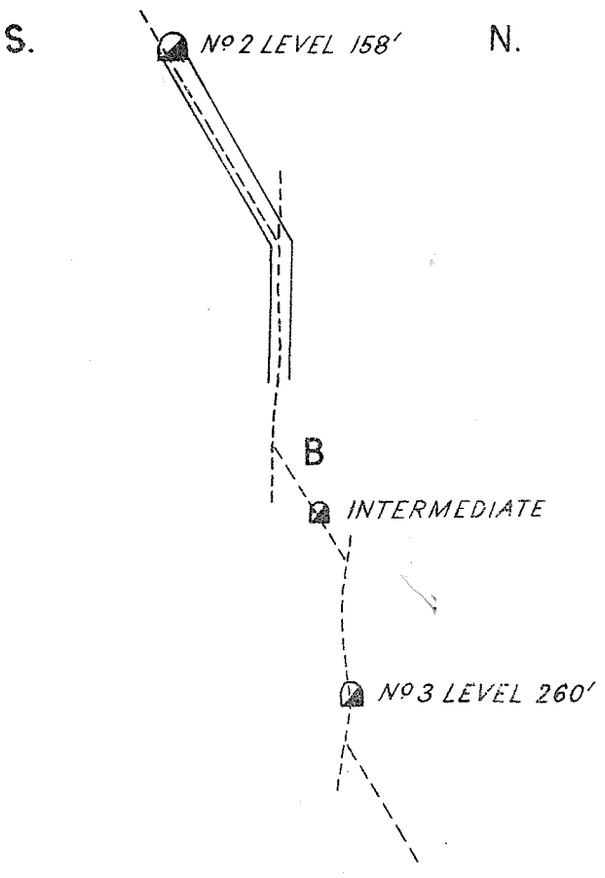

FIGURE 2

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Mackenzie's Lease 1967W.—Uncertainty with regard to the conditions in this lease is caused by the small vertical extent of the workings, and the presence of timbering making it impossible to inspect the ore-body at critical points. However, the shape of the No. 2 level drive from No. 2 main shaft indicates the presence of two dissimilar strikes in the lode channel. The west drive has an average strike of 70°. The strike of the east drive at this level considered together with the corresponding drive at the No. 1 level from the No. 3 main shaft (Hall's) gives an average strike for the eastern section of the ore-body in Mackenzie's lease of 105°. Both the western and eastern sections of the ore-body dip to the north.

There is a close approximation between the two strikes observed in this lease and the strikes of the west and east lode shears in Nicholson's lease, and it is considered that similar structural conditions exist, *i.e.*, that the west drive from the No. 2 main shaft is on a lode occupying a shear which is distinct from and intersects a second lode shear which has been followed in the east drive. This view is supported by the observation of the manager, Mr. H. T. Kingdon, that the values obtained in the east drive were distinctly higher than those in the west drive, the change occurring fairly suddenly just west of the main cross-cut.

The vertical extent of the workings is insufficient to enable the average dips of the eastern and western ore-bodies to be obtained, but it is clear, from the difference in strike of the No. 1 and No. 2 level drives on the east lode, that the dip of this ore-body is not altogether constant. The pitch of the intersection of the west and east lode depends on the difference in dip of the two; and will be to the west or to the east, depending on whether the east lode or the west lode has the greater dip. It is probable that the pitches of the two ore-bodies will follow the pitch of this structural feature. The only dips observed at the No. 2 level were a dip of 80° to the north in the face of the west drive, and a dip of 55° to 60° in the face of the east drive. If these dips represented the average dips of the west and east lodes respectively, their intersection would pitch to the east, and the pitch of the ore-bodies would probably coincide. There is, however, insufficient evidence from which to make a definite decision.

Hall's Lease 1966W.—The ore-body on Hall's lease has an average strike of 105° and dips to the north at 63°. It has been opened up to the No. 3 level (V.D. 260 feet).

At the western end of the drives several small branch lodes have been followed for a short distance, but they have been found soon to lose their values. These branch lodes lie in a weak shear striking at about 140° and which intersects the main lode shear. At the intersection the country rock has been highly fractured and schisted, with the result that the gold bearing solutions have had full opportunity of easy circulation, and a bulge of ore has been formed of considerably greater width than is found elsewhere in the lode.

At the No. 3 level, two east drives have been started from the main cross-cut. The No. 1 east drive (that closer to the shaft) is considered to be the main lode at this level for the following reasons. Firstly, the winze sunk from the No. 2 level west of the main cross-cut followed the "indicator" continuously until it was met by the short rise from the No. 3 level. The "indicator" at this point was left on the hanging wall (north) side of the rise and is therefore more nearly in line with the No. 1 east drive than with the No. 2 east drive. Secondly, the quartz exposed in the No. 1 east drive is similar in appearance to that exposed along the main lode at the Nos. 1 and 2 levels, the quartz in the No. 2 east drive being slightly stained in places with iron oxide. Thirdly, the dip of the lode between the Nos. 2 and 3 levels would require to steepen considerably beyond its dip in the upper levels in order to be in the position of the No. 2 east drive at No. 3 level, whereas the No. 1 east drive is in the correct position of the main lode, assuming that it maintains the dip observed in the upper levels.

The short ore-body opened up in the No. 2 east drive is considered to be the same as the short spur driven on at the western end of the No. 1 level, and which was on the southern or footwall side of the main lode. This spur has apparently been missed or considered not worth driving on at the No. 2 level.

The pitch of the intersection of the cross shear with the main lode at its western end is to the north-east and is obvious from an inspection of the plan. The pitch of the gold values in the main lode channel will probably be found to coincide with this structural pitch. Provided that the ore in the main lode at the No. 3 level is of millable grade, there should therefore be a considerable extent of ore yet available beyond the face of the No. 1 east drive.

The south cross-cut from the No. 3 shaft was examined carefully, but no trace of an easterly extension of Hall's main lode shear could be detected in its expected position. The short east and west drives off the north cross-cut from this shaft are on a narrow shear which may be the western end of a new shear zone, or may be the eastern extension of Hall's lode shear. If the latter be the case then the shear has suffered considerable displacement by faulting.

POSSIBLE UNDEVELOPED ORE-BODIES.

Attention has already been drawn to the possibilities of locating new ore shoots in the western end of Nicholson's west lode and the eastern end of Nicholson's east lode and its extension through Stevenson's lease; also to the possible eastern extension of Nicholson's west lode, a shear which is known to be auriferous to at least some extent from the location of values in the end of the north cross-cut from No. 5 shaft on Stevenson's lease.

Rich patches of alluvial gold have been worked on the north and south sides of the iron-stone capped hill, about a quarter of a mile west of Nicholson's lease on which the treatment plant is situated. The distribution of the alluvial patches makes it appear certain that the gold was shed from one or more ore-bodies located somewhere in the hill. A considerable amount of prospecting work has already been carried out on the hill by means of costeans, adits, and shallow shafts. The direction of a number of the prospecting workings which were briefly inspected suggests that the prospectors were searching for a north-south lode, as almost all the cross-cuts and trenches run in an east and west direction.

All the persistent shears observed in the developed leases strike either north of east or south of east, the actual strikes ranging from 77° to 117°.

It is likely, therefore, that if a payable ore-body exists under the battery hill, it will have a strike within these limits, and prospecting cross-cuts or trenches running generally east and west would most probably fail to locate it. The hill is therefore considered worthy of further prospecting, but all future cross-cuts should be driven in a north and south direction in order to cut possible east and west shears.

SCAHILL'S FELSPAR QUARRY, LONDONDERRY, COOLGARDIE GOLDFIELD.

(F. G. Forman, B.Sc.)

This quarry, which is worked for the production of microcline felspar, is excavated in an extremely coarse grained pegmatite dyke.

The pegmatite consists of quartz, microcline, a little albite and lepidolite. Quartz and microcline are the chief constituents and occur in large masses so that the mining of almost pure microcline without admixture of quartz is an easy operation.

The excavation, which measures approximately 100 by 50 by 15 feet, is situated in a part of the dyke which consists almost wholly of microcline. The quarry has reached its limit on the western side as surface exposures show the remaining dyke material on this side to consist almost wholly of quartz.

The southern end of the quarry, which is the shallowest, still shows a face of microcline felspar, but the mineral is badly iron-stained and would have to be extracted as second grade material.

The eastern side of the quarry shows lower grade material than that obtained in the central portion. The microcline on this side is mixed with lepidolite mica and albite felspar with some quartz, the boundary between the high grade material and the lower grade mixture dipping fairly flatly in a westerly direction. This has apparently been the controlling factor in deciding the depth of the quarry, but judging by the adjacent surface outcrops and from the general nature of the pegmatite dyke, there is good reason to believe that workable microcline could be obtained beneath the present bottom of the quarry; the low grade material forming the present floor being probably in the form of a thin irregular vein in the pegmatite mass. The dyke should be prospected at depth by a shaft sunk in the centre of the quarry floor.

In the northern face, where work is at present concentrated, the masses of quartz and microcline constituting the bulk of the pegmatite are more intimately mixed and of smaller dimensions than in the place originally worked. This has led the proprietor to suppose that the deposit would soon become exhausted in this direction. Inspection of the surface, however, shows that the pegmatite dyke extends some distance further to the north and, while that part of the dyke at present exposed in the north face of the quarry is less coarse grained than where originally opened up, there are at least two large masses of microcline still ahead of the face. These are being prospected by shafts and costeans.

It is suggested that the best method of continuing the quarry is by continued working of the whole of the north face. Greater labour will be required in order to expose the more scattered microcline masses and to discard the useless quartz. This, however, is unavoidable and much to be preferred to the present method of working, which is to locate a mass of microcline and remove it bodily before looking for the next mass by tunnelling. If the present practice is continued the deposit will become unworkable because of the bulk of useless material left in the quarry and the high cost of extraction of the felspar by underground methods. Prospecting ahead of the face by shaft sinking and costeaning is at present being done and should be continued.

It is unfortunate that those parts of the quarry which have been worked out have been used as a dumping ground for refuse from the face. There is probably much valuable felspar below the floor of the quarry, and the refuse will need to be moved before this material can be worked or even thoroughly prospected.

SUB-ARTESIAN WATER POSSIBILITIES ON WINNING STATION, LYNDON RIVER, NORTH-WEST DIVISION.

(F. G. Forman, B.Sc.)

The greater part of Winning Station is underlain by rocks of Cretaceous age; Palaeozoic strata (Permo Carboniferous) outcrop over a relatively small area south of a line joining Windalia Hills and A.50. The distribution of the rocks is shown on the accompanying map of the area.

Wells already drilled on Winning Station, and on adjacent pastoral leases, indicate that the most useful artesian and sub-artesian horizon lies at the base of the Cretaceous Series in a greensand or sandrock, but this horizon has not by any means been fully exploited.

The highest rocks of the Cretaceous outcropping on Winning Station are limestone and shales containing abundant Inoceramus fragments (Cardabia Series). These are underlain by the Winning Series, the upper part of which consists of light-coloured silt-stones, cherts and light grey shales. The lower part of the Winning Series consists of dark green and greenish grey shales and mudstones with thin bands of greensand. It is the lowest band of greensand at the base of the Winning Series from which useful supplies of stock water are obtained. Thin greensand bands carrying intensely salt water occur about 250 feet above the base of the Series. This fact has discouraged boring in a number of localities, particularly at the eastern portion of the property and in what is known as the "9-Mile Paddock."

The Cardabia Series outcrops only on the extreme western portion of Winning Station, west of the "12-Mile" and "Dud" Bores. In this Series there is a greensand lying immediately above a light coloured Inoceramus shale bed which carries small quantities of water, of a quality suitable for stock. This has been tested by two wells on Marilla Station immediately north of Winning, but the supply in both cases was inadequate. This greensand water could be obtained on Winning Station along the western boundary by boring to shallow depth (probably between 100 and 200 feet), but the supply obtainable is not likely to be great, and possibly insufficient for the purpose of watering stock.

The accompanying cross section from west to east through the deeper bores on Winning Station shows that the Winning Series thins rapidly from west to