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Rum Jungle Area Radon Survey, Northern Territory, 1969

by

J. E. F. Gardener

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NORTHERN TERRITORY, 1969

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SUMMARY

In 1969 the Bureau of Mineral Resources conducted experimental surveys in the Rum Jungle area, Northern Territory, to test the radon (or emanation) method of uranium exploration. The method used was to measure alpha particle activity due to radon in holes drilled specially for the purpose. The main areas surveyed were the Rum Jungle Creek/Rum Jungle Creek South area, the Mount Fitch/Mount Fitch North area, and the Crater Formation. The results in the Crater Formation showed that most of the radioactivity is due to the thorium decay series, but small amounts of radon 222 probably occur. In the other areas numerous alpha anomalies were located. Although limited migration by diffusion of radon 222 from nearby sources probably occurs, in general the results are inconclusive because it is not possible to interpret the results to the extent of determining whether migration of radon has occurred or not.

1. INTRODUCTION

In 1969 the Bureau of Mineral Resources (BMR) conducted surveys in the Rum Jungle area, Northern Territory, to test the radon method (often called the emanation method) of uranium exploration. The method is based on the migration of radon. Radon can migrate from its parent radium by transport or diffusion. The radon method is to study the distribution of the radon to find the migration paths and so to locate radium and uranium. Radon is an alpha particle emitter and the method used to locate radon was to measure alpha particle activity in boreholes.

The main areas surveyed (Plate 1) were the Rum Jungle Creek/Rum Jungle Creek South area, the Mount Fitch/Mount Fitch North area, and the Crater Formation north and east of Batchelor.

The element radon has three naturally occurring isotopes, all radioactive: radon 222 (radon), radon 220 (thoron), and radon 219 (actinon). These isotopes are produced in the decay series of uranium 238, thorium 232, and uranium 235 respectively and all are alpha emitters. Their half lives are 3.825 days, 54.5 seconds, and 3.92 seconds respectively. The amount of radon 219 occuring naturally is insignificant for the purposes of radon surveys.

Radon isotopes are inert gases. During their brief lives the atoms are capable of moving from the sites of generation by diffusion and transport through permeable rock and soil. The migration of radon 220 and radon 219 in the ground is severely restricted, in comparison with that of radon 222, by their short half lives.

Radon is soluble in water but the solubility is a steep inverse function of temperature. Radon is less soluble in aqueous solutions of electrolytes than in pure water.

Many variables are significant in the migration of radon isotopes (Tanner, 1964a, p. 165): the decay rate of the isotope, the diffusion constant for the isotope in the pore-filling fluid, the porosity of the ground, the velocity of the fluid, the composition of the fluid and, if the fluid has more than one phase, the temperature-dependent distribution of the radon isotope among the phases. Two different mechanisms of migration should be distinguished: diffusion, where the radon isotope moves with respect to the fluid filling the pores of the medium; and transport, where the fluid itself moves through the porous medium and carries the radon isotope along with it.

Tanner (1964a, p. 174) summarizes estimates, based on experimental and theoretical work, of migration distances of radon 222 in a homogeneous, isotropic, porous, permeable medium (for example, undisturbed rock or soil). The maximum distance at which radon in soil gas would signal a buried deposit of radium-bearing material is to the order of ten metres. The migration distance of radon 222 in liquid-saturated rock or soil depends on the rate of flow of the underground liquids; this is variable and depends on local conditions, but the maximum is estimated at about two metres per day. The migration distance also depends on the rate of removal of radon from underground water. Tanner (1964a, p. 173) concludes that the migration distances of the radon isotopes are quite short at normal groundwater flow rates.

No reliable estimates can be made of the migration distance of the radon isotopes in anisotropic and fractured media. In unsaturated, fractured rock or disturbed soil, channels may be present in the ground in the vicinity of a source of a radon isotope and migration will be unusually great along the high-speed paths, but only in the directions traversed by those paths. The chance of detecting a radon anomaly at a distance greater than would be found for a homogeneous, isotropic medium will depend on the chance that a sample is taken at a fracture or channel. The migration of radon isotopes in saturated anisotropic and fractured rock or soil depends heavily on the rate of groundwater flow along preferred channels, and the proximity of the channels to radon sources.

Tanner (1964a, p. 178) reviews geophysical prospecting for uranium using radon detection methods. He states that "the success of many of the geophysical investigations cited (by him) suggests that substantial radon migration takes place. Few of the investigations, however, have permitted discrimination between migration of radon and that of its precursors. Migration of the several most mobile members of the uranium series, uranium 238, uranium 234, radium 226, and radon 222, is probably responsible for many anomalies, particularly those which imply movement through distances of many metres."

"Radon migration may even be minor compared with migration of its precursors in some places. In a survey at a uranium prospect in Texas, the writer (Tanner) found a halo of enhanced radon concentration in soil gas at all sampling points within about 30 metres of a uranium ore body. Without further knowledge the halo might have been ascribed to radon migration. However, the vertical distribution of radon in the ground was inconsistent with upward radon migration of more than a few centimeters, and the horizontal gradient of radon concentration was inadequate to account for the anomaly. Displacement of the anomaly in the downhill direction, correspondence between the gamma-ray intensity and radon concentrations in holes near each other, and uranium series disequilibrium at the prospect indicated that the anomaly resulted from the migration of the precursors of radon."

"Uranium series disequilibrium prevails in and about many uranium ores (Rosholt, 1959; Granger, 1963). Groundwater movement is common in fault zones such as are likely to be revealed by the emanation method. Anomalies arising from the migration of radon only should probably be regarded as exceptional."

Uranium series migration and disequilibrium are interconnected. Two main types of disequilibrium are (1) uranium daughter-product deficiency and (2) uranium deficiency.

Uranium daughter-product deficiency can be caused by various processes. The uranium may have migrated to its present location in a time less than that required by its daughter products to reach approximate equilibrium. Alternatively, preferentially greater leaching of daughter products than of uranium may have occurred; this alternative is the more probable in carnotite and other types of deposits where uranium-fixative agents (such as vanadium or phosphate) are also present. Radium 226 has been found to be the most common long-lived daughter product which can be leached (Rosholt, 1959, p.10); deficiencies of radon 222 and of lead 210 (due to emanation of radon 222) are causes of only short-lived disequilibrium. Granger (1963, p.62) gives examples of radium 226 migration and of the subsequent concentration, under suitable conditions, of radium 226 not associated with parent isotopes. Under certain conditions, thorium 230 (the parent of radium 226) is also mobile (Granger, 1963, p. 61).

Disequilibrium due to uranium deficiency is often the result of leaching of uranium. This type of disequilibrium is usually associated with an oxidized environment; it can also occur in pyritic ores from the differential leaching of all components. Sulphates formed would retain the radium even though it might migrate somewhat, whereas the sulphuric acid formed would leach and remove uranium (Rosholt, 1959, p.13).

Radium 226 is easily leached in many different environments (Rosholt, 1959, p.13) and is quite mobile. One of the many processes that can remove radium 226 from water and immobilize it is precipitation as radium sulphate, as mentioned above (Tanner, 1964b, p. 271). A common mechanism of radium immobilization is coprecipitation of radium 226 with calcium carbonate (Tanner, 1964b, p. 272).

Two of the principal gamma emitters in the uranium decay series are the radon 222 daughters, lead 214 and bismuth 214; therefore gamma anomalies can be expected to occur associated with radon 222. The strength of the gamma anomalies can be expected to depend to some extent on the distribution of the radon 222 in the ground; this is related to the diffusion or transport rate of the radon.

In the USSR the radon method has found wide practical application, more so than in other countries (Tanner, 1964a, p. 177). Grammakov et al. (1958, p. 737-738) refer to the investigation in the USSR of the relationship between radon and radium haloes. The interpretation of their radon data is based not only on the activity of the orebody and the rate of radon diffusion but also on the radium distribution in the ground. They state that often the determination of the relationship between the radioactivities of the gaseous and solid phases is one of the most important steps in their interpretation.

2. METHOD AND EQUIPMENT

The method used to measure radon was to lower an alpha-sensitive probe down boreholes in the areas under investigation. The probe was connected to a power supply and counter on the surface.

The equipment for the Rum Jungle area survey was lent to the Bureau of Mineral Resources by the Australian Atomic Energy Commission. The alpha-sensitive area of the probe was a layer of zinc sulphide on the cylindrical surface of the one-inch diameter perspex rod eight inches long. The scintillation layer was shielded from light by aluminized mylar foil of one milligram per square centimetre equivalent surface density. A one-inch diameter photo-multiplier tube was optically coupled to one end of the perspex rod. An outer cylindrical housing, 2¼ ins in diameter and perforated in the vicinity of the alpha-sensitive surface, was fitted over the probe. A fine metal gauze covered the perforated area. The housing provided mechanical protection and defined a fixed volume of gas for measurement. The probe was lowered down the hole with a steel cable. A coaxial cable approximately 30 ft long connected the probe to the electronic equipment on the surface. This consisted of a power supply for the photo-multiplier tube and a pulse-counting unit.

A protactinium 231 alpha source was provided to check the sensitivity of the probe. Checks made by the Australian Atomic Energy Commission in their laboratory in a simulated borehole filled with radon 222 in air showed that the sensitivity of the probes was about 500 counts per minute per nano curie per litre.

Most of the borepholes used for radon measurements were auger holes drilled specifically for the purpose. Gamma measurements were made in the holes immediately after drilling and the holes were then covered to avoid scavenging of the borehole gas due to venturi effects of the wind. The alpha reading were usually made twenty-four hours after the holes had been drilled and covered to allow a steady state condition to be reached. The auger holes were nominally 29 ft deep, but the actual depth depended on drilling conditions and the limitations of the auger drill used.

Tests made in selected holes over a period of months showed that meteorological effects did not measurably affect radon readings below 10 ft in the holes. However, this was in the dry season when weather conditions were stable. Heavy rain saturating the ground, variations in depth to water in boreholes, and variations in atmospheric pressure could be expected to influence the radon content in the holes; Tanner (1964a, p. 169) reviews these problems.

Deposition of solid alpha-active daughters of radon in the probe causes a build-up of count rate and also contaminates the probe. Thus the longer the probe is down the hole the greater the count rate will be; equilibrium between radon and its daughters down to lead 210 is reached in about four hours. The count rate is thus a function of the time elapsed between putting the probe down the hole and starting the count; it is also a function of the counting time. These times were usually half a minute and three minutes respectively.

Contamination of the probe is due to deposition of solid alpha-active daughters of radon on the surfaces of the probe. This contamination is taken into account by background readings before making a reading in a borehole. The daughters are short-lived and the time-dependence of the contamination has been measured. The alpha readings are made when the contamination has reached a slow, steady rate of decrease.

Thermal agitation in the hole stirs up the gas, but measurements showed that highest count rates were at the bottom of the holes; the count rate is a function of the depth of the probe down the hole. As the probe is not waterproof, the maximum depth of the probe in the hole is limited by the depth to water. Measurements were made as near as possible to the bottom of the holes. In dry holes, the only limitation was the length of the coaxial cable connecting the probe to the surface electronic equipment (about 25 ft). In wet holes, measurements were made about one foot above the water level except, of course, when the water level was deeper than the cable length. The accuracy of the method was not great, but, in practice, it was possible to distinguish between holes with low and high count rates.

The method used to differentiate between radon 220 and radon 222 in the field was to trap gas from a borehole in the probe and measure the alpha activity of the daughter products over some hours to establish half lives. After the probe is removed from the hole, the time-dependence of the count rate is complex for the first few hours owing to disequilibrium between the various isotopes. Radon 222 decays to polonium 218, to lead 214, to bismuth 214, to polonium 214, to lead 210, etc. Radon 222 and polonium 218 and 214 are alpha emitters, and lead 214, bismuth 214, and lead 210 are beta emitters. The half lives of the isotopes are such that after the decay series of radon 222 and its short-lived daughters (that is, down to polonium 214) reaches equilibrium, the alpha count rate in the probe decreases at a rate depending on the half life of the beta producer, lead 214. Similarly, radon 220 decays to polonium 216, to lead 212, to bismuth 212, etc. and the half lives of the isotopes are such that after the decay series of radon 220 and its short-lived daughter polonium 216 reaches equilibrium, the alpha count rate in the probe decreases at a rate depending on the half life of the beta producer, lead 212. The half life of lead 214 is 26.8 mins and that of lead 212 is 10.6 h and measurement of these half lives differentiates between the parents of lead 214 and lead 212 (and so between radon 222 and radon 220). As the decay is exponential, the alpha intensity of a particular half life plotted logarithmically against time produces a straight line of negative slope; examples are shown in Plate 8. In the cases in the Crater Formation where lead 214 and 212 are both present, the total intensity is plotted logarithmically and the slope of the plot gives a half life of 10.6 h.; this is because almost all the alpha activity is due to the radon 220 decay series. However, if the straight line plot of the 10.6 h. half life is subtracted from the total intensity plot, the result should be a plot giving a half life of 26.8 mins. Examples of this are shown in Plate 8.

3. RESULTS

Initial Tests

The Australian Atomic Energy Commission made a brief field test of the radon equipment at the end of February 1969 in the Rum Jungle area. A line of auger holes was drilled across the Mount Fitch prospect and another line in the Crater Formation immediately north of Batchelor. Radon measurements were made in these holes and in existing diamond-drill holes in the area of Mount Fitch prospect.

The tests were concerned only with the physical measurement of radon concentrations. The conclusion reached was that measurement of radon concentrations under field conditions is relatively straightforward (J.K. Parry, pers. comm.).

Crater Formation

The radon survey proper began in July 1969 in the Crater Formation. Two lines of auger holes were drilled, one at the Crater prospect (Crater traverse No.1) and one in the Shirley area (Crater traverse No. 2). Holes were 50 ft apart except towards the ends of the traverses where they were 100 ft apart. The positions of the traverses are shown in Plate 1. Gamma and alpha measurements were made in the holes and the results are shown in Plate 2. The geology shown, by D.J. French, is from Needham's (1970) Plate 28.

Plate 2 shows anomalies in the down-hole alpha and gamma readings, and the surface gamma readings due to radioactivity in the Crater Pebble Beds and the beds immediately above them. The No. 1 and No. 2 Conglomerates form narrow discontinuous beds. The surface gamma readings show anomalies due to both Conglomerates on Traverse 1 and to the No. 1 Conglomerate on Traverse 2; the No. 2 Conglomerate did not crop out on this traverse. The down-hole gamma readings show an anomaly only on the No. 1 Conglomerate on Traverse 1. Evidently the holes missed the other occurrences of the Conglomerates. No down-hole alpha reading was made in the hole on the No. 1 Conglomerate on Traverse 1 because it caved in.

Measurements of half lives of daughters in the decay series of gas in the probe were made as described earlier. The results (Plate 8) show that the alpha activity is due to radon 220, a member of the thorium 232 decay series. However, subtracting the 10.6 half life curve from the total alpha activity curve shows that some activity may be due to radon 222, but this is somewhat uncertain because the count rates are so low that significant statistical errors may be present. These measurements were made in auger holes at 0.5N, Traverse1, and at 6.5N, Traverse 2, and in rotary hole 69R36, which is about 300 ft west of 6.5N, Traverse 2. All these holes were in the anomalous zone.

For comparison, measurement was made of half lives of daughters in a sample of gas from rotary hole R140 (drilled in 1968) at Rum Jungle Creek South. The position of the hole is shown in Plate 3. The results, shown in Plate 8, are totally different from those from the Crater Formation and clearly show a half life of about 27 min.

The positions of the alpha and gamma anomalies coincide well. As the radioactivity is due mainly to the thorium decay series this is to be expected. The half life of radon 220 (thoron) is so short that migration is negligible.

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At this stage, alpha measurements were stopped in the Crater Formation because of the presence of the activity due to the thorium 232 series, and measurements were started in the Rum Jungle Creek/ Rum Jungle Creek South area.

Rum Jungle Creek/Rum Jungle Creek South area

Holes were drilled as shown in Plate 3 around and to the northwest of the Rum Jungle Creek South open cut. The holes are all auger holes except the group of rotary holes on Traverses 40E, 42E, 44E, and 46E south of the open cut. The geology of the area is shown in Plate 4, which is Needham's (1970) Plate 24. The area includes the Golden Dyke Formation and its contact with Coomalie Dolomite to the south and hematite quartz breccia to the north, and also the syncline in the Golden Dyke Formation in which the Rum Jungle Creek South orebody occurs..

Alpha and gamma measurements were made in the holes; results are shown in Plate 3. These results show the alpha activity in each hole, the maximum gamma activity in each hole and the depth at which it occurred, and the gamma activity at the bottom of each hole and this depth. Holes with alpha activities of 1000 counts per minute (cpm) and over are marked as anomalous. Although activities of about 600 cpm and over are probably anomalous, less ambiguity arises in interpretation if only the definitely anomalous holes are considered.

No gamma readings are shown for the rotary holes on Traverses 40E to 46E. The water-table depth on these traverses ranges from 20 ft on the western ends to 40 ft on the eastern ends; all the gamma maxima are well below the water-table. Radon emanation in these holes is from material on the sides of the holes or from the top of the water in the holes, and gamma anomalies below the water-table are not relevant except in so far as they may influence the radon content of the water.

Alpha anomalies occur in most of the rotary holes south of the Rum Jungle Creek South open cut. Gamma peaks in the holes vary greatly in occurrence and intensity and cannot be matched between adjacent holes, suggesting radioactivity of a small poddy nature (Needham, 1970, p.29). The holes are in the southern extension of the Rum Jungle Creek South uranium mineralization. Although the maximum gamma readings are below the water-table, the soil here is known to be anomalous. Ruxton & Shields (1963, p.11) consider that radioactive minerals have migrated downslope laterally from about 8N/40E towards 4N/40E along the soil/bedrock boundary (about 10 ft depth) and gradually upwards through the soil. The alpha anomalies here are probably due to radon from radium at about 10 ft depth. The gamma anomalies in the soil are probably from radon daughters. The area is known to contain sporadic low-grade uranium mineralization (Miezitis, 1967). It appears that neither the radium nor the radon here has migrated far.

A traverse (A-J) skirting the open cut and waste tip areas and crossing a paddock of Meneling Homestead was auger-drilled. The position of the traverse is shown in Plates 3 and 4; the radiometric results are shown in Plate 3. Numerous near-surface gamma anomalies occur and these, except for the one around AB200 discussed below (AB200 is 200 ft from A towards B), are either a result of surface contamination from the mining operations or are similar to the anomalies in soil south of the open cut and discussed above, or a combination of both. The alpha readings are variable, the highest being at AB800, AB1000, BC600, EF250, and FG200. Near-surface concentrations of radium could account for these anomalies; the gamma counts are mainly from daughters.

The radiometric anomalies around AB200 and AB200/400E were known before mining operations commenced. Sporadic high- and low-grade uranium mineralization, mainly between 140 and 210 ft, occurs in this area (Miezitis, 1967, p. 67). Plate 3 shows that high gamma readings occur in the first few feet of each hole, and concentrations of near-surface radium probably account for at least part of these anomalies. In addition diffusion of radon from nearby radium associated with minor uranium mineralization and from the water-table (arising from deeper mineralization) probably occurs.

Radiometric anomalies occur at the Rum Jungle Creek prospect (Plate 3). Miezitis (1967) summarizes the exploration here and states (p. 68) that sporadic low-grade uranium mineralization was found at the prospect. High gamma readings occur all the way down holes 9N/8W, 6N/4W, 9N/4W, and 8N/1W and high alpha readings (up to 4,500 cpm) were obtained in these holes. These strong gamma anomalies are not related to commercial-grade uranium mineralization and are probably associated with the uranium decay series in disequilibrium. Strong concentrations of radium could produce the radon for the strong alpha anomalies. If the radon does not diffuse far, then the strong gamma anomalies would result from the gamma-emitting radon daughters.

A very high alpha reading (7,500 cpm) was obtained in the hole at 10.5N/22E, and high gamma counts were obtained all the way down the hole. This hole is adjacent to hematite quartzite breccia of the Castlemaine Beds (described by Needham, 1970, p.9). Ruxton & Shields (1963, p. 11) describe an auger hole in a similar geological position at 26.75E/10.85N (Rum Jungle Creek South grid), adjacent to the hematite quartzite breccia and about 950 ft south along the contact from 10.5N/22E. The hole described by Ruxton & Shields passed through silts and clays. The average radiometric reading was above 0.096 mR/h (somewhat higher than the 1969 hole). The silt between one and three feet was found to contain 28 percent P_2O_5 and that between 10 and 14 ft, 22 percent P_2O_5. The 1969 hole may be similar and the radioactivity could be associated with uranium fixed by the phosphorous. Alternatively the radioactivity could be similar to that at the Rum Jungle Creek prospect described above.

A group of holes with alpha anomalies is shown in Plate 3 on and south of the Rum Jungle Creek grid baseline from 4E to 20E. These anomalies are on the flood-out of the small creek shown. This creek rises in the Castlemaine Beds (known to contain uranium mineralization associated with phosphate) and crosses the Golden Dyke Formation just east of the Rum Jungle Creek prospect. It is possible that some of the radioactivity in the flood-out area is from radioactive material washed down the creek. The anomalous holes are mostly in Golden Dyke Formation. One of the holes (4S/16E) has gamma values increasing with depth, and the gamma anomaly was later investigated by deeper rotary drilling. This revealed isolated gamma anomalies, and the area may contain weak sporadic uranium mineralization (Needham, 1970, p. 28). Most of the auger holes show gamma anomalies in the first 10 to 15 ft, and the radioactivity may be due partly to sporadic weak mineralization and partly to near-surface radioactivity from uranium series decay products out of equilibrium.

Other holes with high alpha readings not yet mentioned are at 12S/16W, 0/4W, 8S/4W, 8N/12E, and 4N/16E. The anomalies may be associated partly with radioactivity in the near-surface layers and partly with deeper radioactivity, as in the previous cases.

Plate 5 shows the gamma logs of holes along Traverse 8S across the flood-out mentioned previously. The logs show anomalies only in the near-surface zones. The alpha anomalies indicate the presence of radon; the gamma anomalies could indicate the presence of the radon daughters bismuth 214 and lead 214 in the top 15 ft or so. Thus on this traverse both the alpha and gamma readings could be interpreted as an indication of the presence of radon. Neither the alpha nor the gamma readings indicate whether migration of radon or of its precursors has taken place. The gamma log of the auger hole at 4S/16E (Pl. 3) showed maxium radioactivity of 0.05 mR/h at the bottom of the hole (18 ft); the alpha reading was 2600 cpm. A series of deeper rotary holes was drilled subsequently at 400-ft centres along Traverse 4S to test the gamma anomaly; the only significant radioactivity located was 0.14 mR/h between 118 ft and 119 ft at 4S/8E (Needham, 1970, p. 28). It is possible that some radon migration occurs from this and other radioactive material at depth and contributes to the auger hole alpha anomalies. The presence of deeper radioactivity cannot be inferred from either the alpha or the gamma readings in the auger hole. Essentially, all the information obtained from interpretation of the alpha results was also available from interpretation of the gamma results.

Mount Fitch/Mount Fitch North area

Auger holes were drilled as shown in Plate 6 on traverses crossing the Coomalie Dolomite/Golden Dyke Formation boundary. The geology shown is from Needham's (1970) Plates 22 and 23. Alpha and gamma measurements were made; the results are shown in Plate 6. Holes with alpha readings of 1000 cpm and over are marked as anomalous as in the Rum Jungle Creek/Rum Jungle Creek South area.

The area has been thoroughly prospected and all gamma anomalies are known from previous surveys. The gamma logs show high values occurring in the Golden Dyke Formation; the 0.03 mR/h contour closely parallels the Coomalie Dolomite/Golden Dyke Formation boundary (Needham, 1970, p. 26, and pl. 21). The alpha results do not correlate so readily with the geology. In the northern part of the surveyed area, alpha anomalies were found at the Mount Fitch North prospect (Traverse 544N, pl. 6). This prospect has been well tested by Territory Enterprises Pty Ltd and only minor uranium mineralization was found (Miezitis, 1967, p. 5). South of Traverse 544N, occasional alpha anomalies were found as far as Traverse 490N. All these anomalies may well be associated with minor uranium mineralization. Alpha anomalies occur more consistently from Traverse 482N southwards. This is in an area of known minor mineralization north of the Mount Fitch prospect. No auger holes were drilled at the prospect itself because of preliminary mining operations going on at the time, but auger holes were drilled to the east and north as shown. Secondary uranium mineralization is known to occur in the Coomalie Dolomite immediately east of the Mount Fitch prospect, and the numerous alpha anomalies may be due to radon which has not migrated any significant distance. No gamma logs were made in the holes immediately east and north of the prospect, but from previous survey results summarised by Miezitis (1967, pl. 3a) the area is known to be highly anomalous. A general interpretation of the alpha and gamma anomalies is that they are associated with radioactive haloes around the Mount Fitch prospect.

About a quarter of a mile south of the Mount Fitch prospect, alpha anomalies were found on Traverse 418N. High readings were obtained in the holes at 136E, 134E, 132E, and 131E in the Crater Formation.

High readings were obtained also at 137E in the Rum Jungle Granite Complex; these may be due to radioactivity in the Complex or in the nearby Crater Formation. Alpha anomalies were also found in the Acacia Gap Tongue at 127E, 126E. The reason for these is unknown; the Acacia Gap Tongue is described on this traverse as quartzite and black slate (Needham, 1967, pl. 23). One alpha anomaly was found in the Golden Dyke Formation (at 113E), though all the alpha readings in the Golden Dyke Formation here were fairly high.

Rum Jungle East area

Alpha measurements were made in one line of auger holes (20W) in the Huandot area, Rum Jungle East. The approximate position of the traverse is shown in Plate 1, and the radiometric results in Plate 7. The traverse (from north to south) is in Golden Dyke Formation and the transition zone between Golden Dyke Formation and Coomalie Dolomite. The results show associated high alpha and gamma anomalies at around 290S in the Golden Dyke Formation, with an associated surface gamma anomaly. The anomalies are interpreted as being due to radioactive material in the near-surface soil, between 10 and 15 ft depth, with the maximum radioactivity located in a particular soil layer (Needham, 1970, pp. 14-15). The alpha activity probably comes from radon emanating from radium in the soil.

4. CONCLUSIONS

In the Crater Formation the alpha activity is due mainly to radon 220 (thoron). Field tests made by determining decay curves of radon daughters showed that small amounts of radon 222 probably occur in the Crater Formation. No quantitative estimate could be made from the tests.

In the other areas surveyed, limited radon 222 migration by diffusion has probably occurred from nearby radium in many cases, for example, at the known occurrences of uranium mineralization such as the Rum Jungle Creek prospect, the northern and southern extensions of the Rum Jungle Creek South mineralization, the Mount Fitch North prospect, and the holes around the Mount Fitch prospect. However, in general it is not possible to interpret the results to the extent of determining whether migration of radon or of its precursors has occurred over significant distances or not.

An interpretation of the Rum Jungle area results could be that the existence of the radon anomalies indicates the existence of uranium mineralization. Exploration has shown this mineralization to be widespread in the area, though mostly uneconomic. Probably innumerable radium and radon haloes exist around mineralization, generally overlapping adjacent haloes. Thus the widespread distribution of uranium mineralization, mostly minor, hampers detailed interpretation of results to locate individual mineralized zones.

Two of the principal gamma emitters in the uranium decay series are the radon 222 daughters, lead 214 and bismuth 214, and therefore gamma anomalies can be expected to occur associated with radon 222 anomalies. As it is simpler to make gamma measurements than alpha measurements, in general gamma measurements are preferred.

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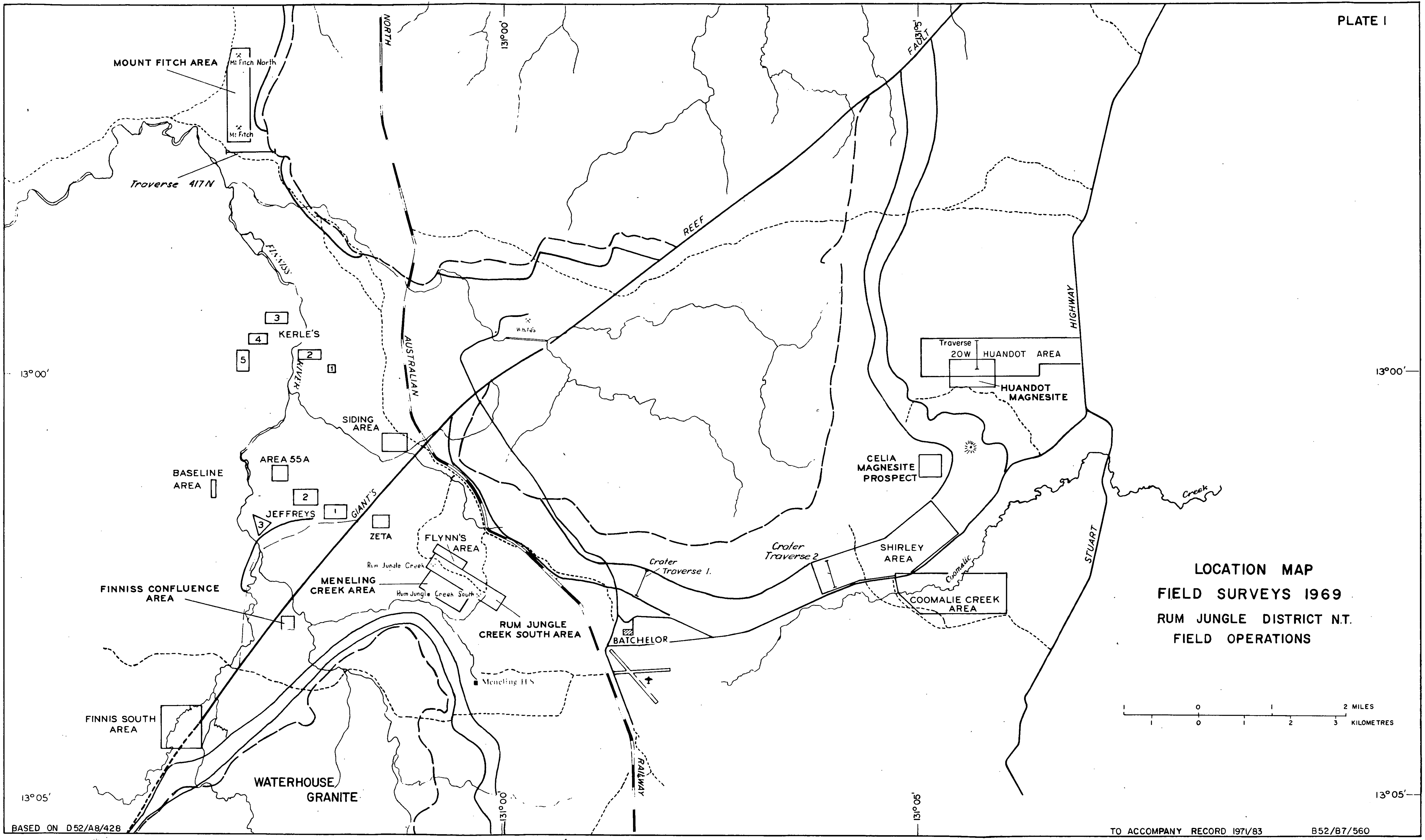
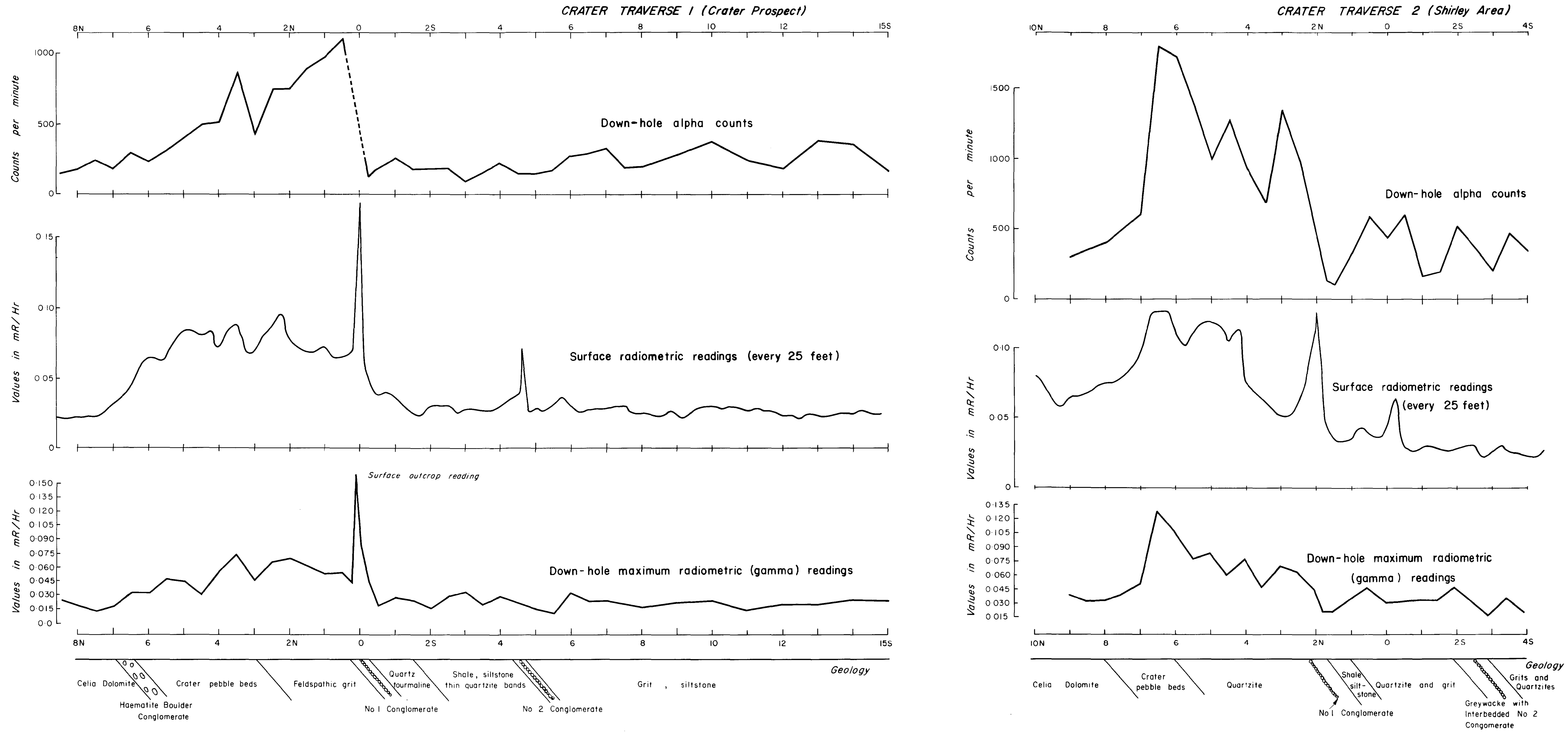


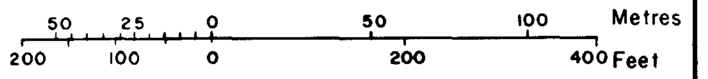
PLATE I
MOUNT FITCH AREA
Mt Fitch North
Mt Fitch
Traverse 417N
NORTH
AUSTRALIAN
RAILWAY
131°00'
131°05'
13°00'
13°05'
FAULT
REEF
FINNISS
RIVER
KERLE'S
3
4
5
2
1
SIDING AREA
AREA 55A
BASELINE AREA
2
1
3
JEFFREYS
GIANT'S
ZETA
FLYNN'S AREA
Rum Jungle Creek
MENELING CREEK AREA
Rum Jungle Creek South
RUM JUNGLE CREEK SOUTH AREA
FINNISS CONFLUENCE AREA
FINNIS SOUTH AREA
WATERHOUSE GRANITE
Meneling H.S.
BATCHELOR
Whites
Crater Traverse 1.
Crater Traverse 2
SHIRLEY AREA
COOMALIE CREEK AREA
Coomalie
Creek
CELIA MAGNESITE PROSPECT
Traverse 20W
HUANDOT AREA
HUANDOT MAGNESITE
HIGHWAY
STUART
LOCATION MAP
FIELD SURVEYS 1969
RUM JUNGLE DISTRICT N.T.
FIELD OPERATIONS
1 0 1 2 MILES
1 0 1 2 3 KILOMETRES
BASED ON D52/A8/428
TO ACCOMPANY RECORD 1971/83
B52/B7/560

PLATE 2



CRATER TRAVERSES

RADIOMETRIC RESULTS



Geology by D. J. French

TO ACCOMPANY RECORD 1971/83

D52/B7-544

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PLATE 3
RUM JUNGLE CREEK PROSPECT
ORE DUMP
RUM JUNGLE CREEK SOUTH OPEN CUT
OVERBURDEN TIP
Baseline 00
Rum Jungle
Creek
Meneling Creek
B R.J.C. grid
C R.J.C. compass extended
D R.J.C.S. grid
E Local traverse
Major grid : TEP Mine Grid
LEGEND
Drill hole with following readings: 1400 057(9) 013(23)
1400 Alpha reading 1400 cpm
057(9) Maximum down hole gamma reading 0·057mR/Hr at 9 feet
013(23) Bottom of hole gamma reading 0·013mR/Hr at 23 feet
Drill hole with alpha reading of 1000 cpm and over.
Fault
RUM JUNGLE CREEK / RUM JUNGLE CREEK SOUTH
AREA
RADIOMETRIC RESULTS
Metres
Feet
TO ACCOMPANY RECORD 1971/83
D52/B7-545

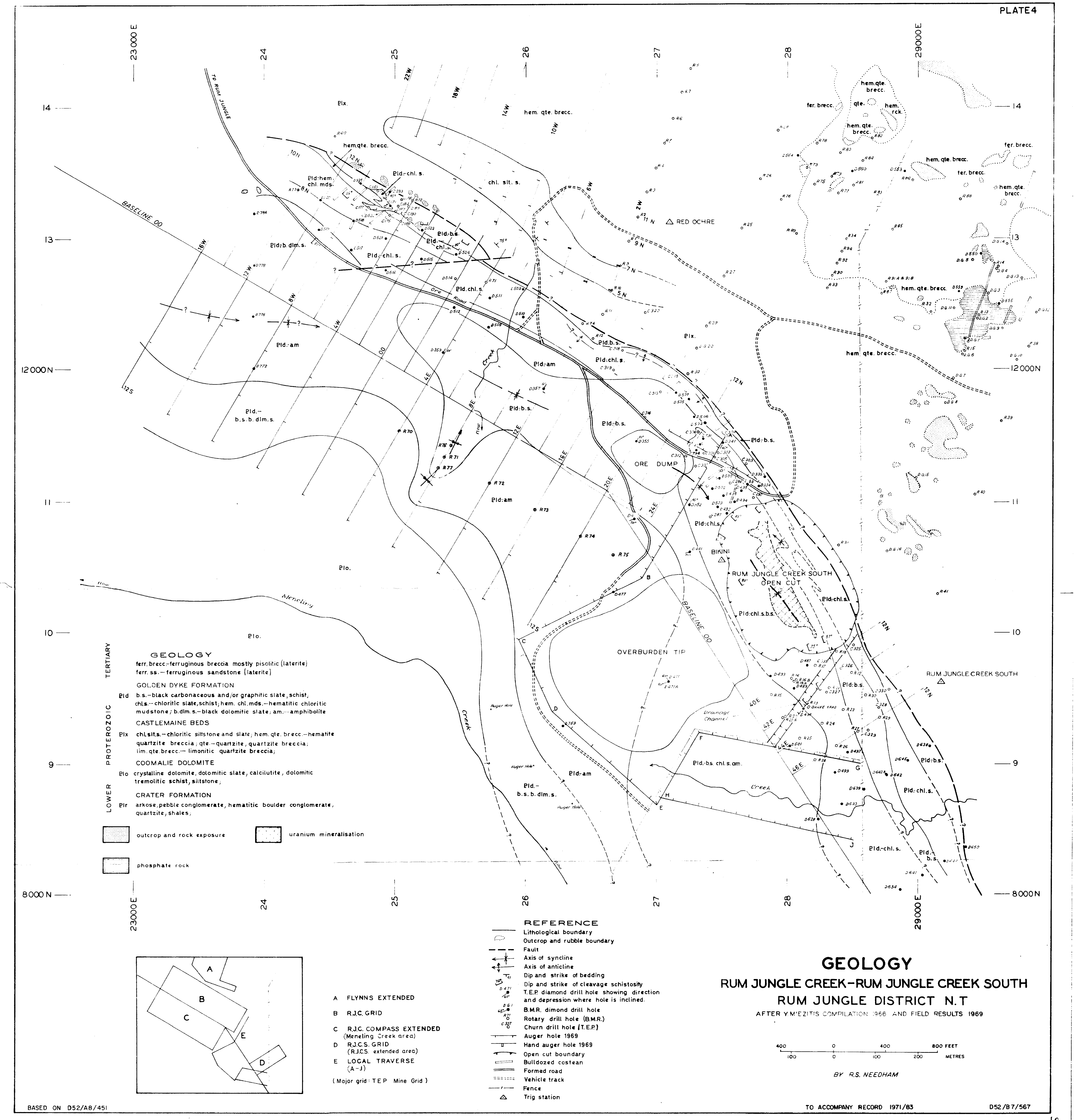

PLATE 4
GEOLOGY
RUM JUNGLE CREEK–RUM JUNGLE CREEK SOUTH
RUM JUNGLE DISTRICT N.T
AFTER Y.M'EZITIS COMPILATION 1966 AND FIELD RESULTS 1969
BY R.S. NEEDHAM
GEOLOGY
TERTIARY
ferr. brecc.–ferruginous breccia mostly pisolitic (laterite)
ferr. ss.–ferruginous sandstone (laterite)
LOWER PROTEROZOIC
GOLDEN DYKE FORMATION
Eld b.s.–black carbonaceous and/or graphitic slate, schist, chl.s.–chloritic slate, schist; hem. chl. mds.–hematitic chloritic mudstone; b.dlm.s.–black dolomitic slate; am.–amphibolite
CASTLEMAINE BEDS
Elx chl.slt.s.–chloritic siltstone and slate; hem. qte. brecc.–hematite quartzite breccia; qte.–quartzite, quartzite breccia; lim. qte. brecc.–limonitic quartzite breccia;
COOMALIE DOLOMITE
Elo crystalline dolomite, dolomitic slate, calcilutite, dolomitic tremolitic schist, siltstone;
CRATER FORMATION
Elr arkose, pebble conglomerate, hematitic boulder conglomerate, quartzite, shales;
outcrop and rock exposure
uranium mineralisation
phosphate rock
REFERENCE
Lithological boundary
Outcrop and rubble boundary
Fault
Axis of syncline
Axis of anticline
Dip and strike of bedding
Dip and strike of cleavage schistosity
T.E.P. diamond drill hole showing direction and depression where hole is inclined.
B.M.R. dimond drill hole
Rotary drill hole (B.M.R.)
Churn drill hole (T.E.P.)
Auger hole 1969
Hand auger hole 1969
Open cut boundary
Bulldozed costean
Formed road
Vehicle track
Fence
Trig station
A FLYNNS EXTENDED
B RJC GRID
C RJC COMPASS EXTENDED (Meneling Creek area)
D RJCS GRID (RJCS extended area)
E LOCAL TRAVERSE (A–J)
(Major grid: TEP Mine Grid)
400 0 400 800 FEET
100 0 100 200 METRES
RUM JUNGLE CREEK SOUTH OPEN CUT
ORE DUMP
OVERBURDEN TIP
RED OCHRE
BIKINI
RUM JUNGLE CREEK SOUTH
BASELINE 00
TO RUM JUNGLE
Meneling Creek
23000 E
29000 E
8000 N
12000 N
BASED ON D52/A8/451
TO ACCOMPANY RECORD 1971/83
D52/B7/567
P.M.A. DARWIN NT 1969 PH.FUCHS

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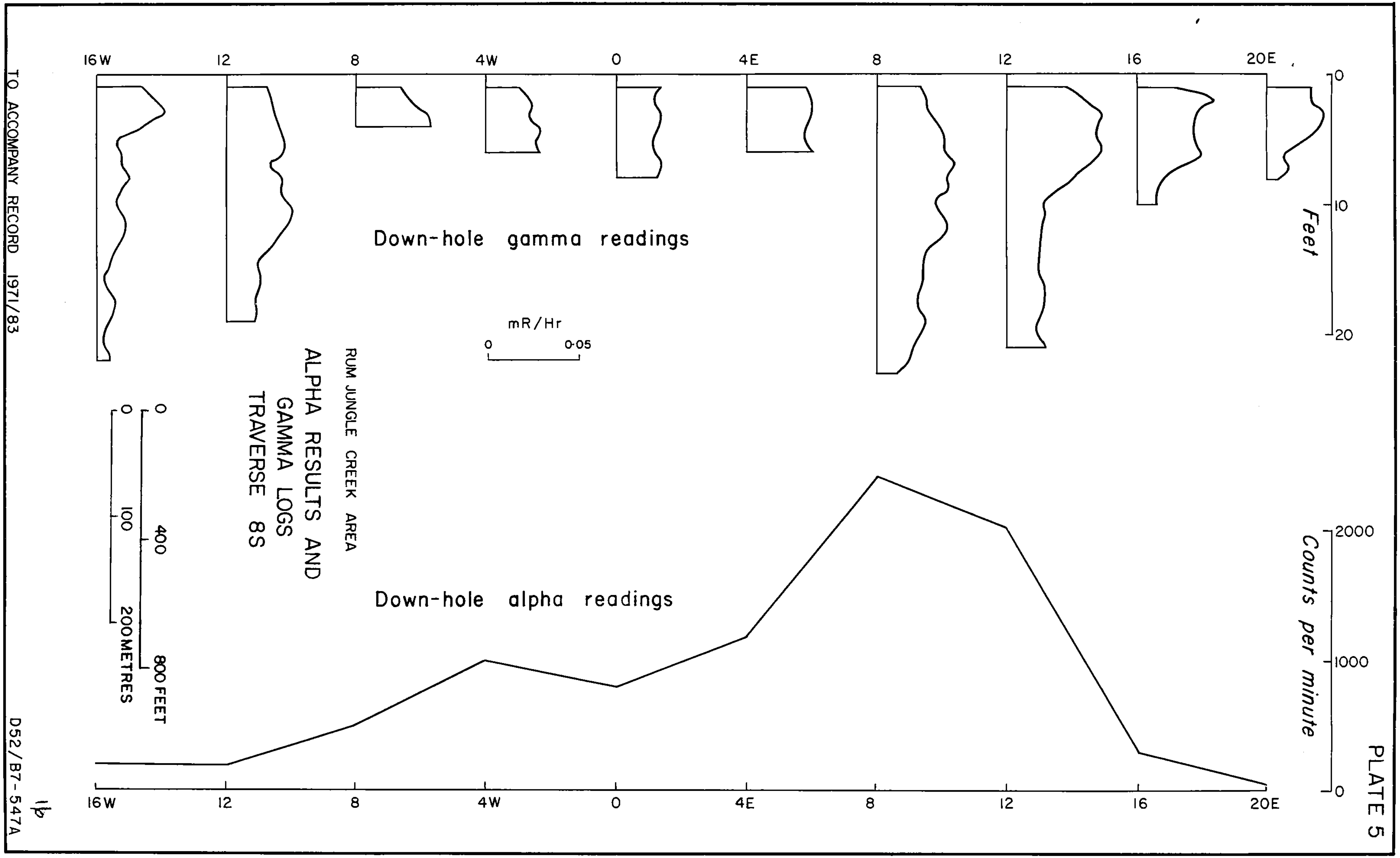

TO ACCOMPANY RECORD 1971/83
PLATE 5
RUM JUNGLE CREEK AREA
ALPHA RESULTS AND
GAMMA LOGS
TRAVERSE 8S
Down-hole gamma readings
Down-hole alpha readings
16W
12
8
4W
0
4E
8
12
16
20E
Feet
0
10
20
mR/Hr
0
0·05
Counts per minute
0
1000
2000
0
400
800 FEET
0
100
200 METRES
D52/B7-547A

PLATE 6


MOUNT FITCH/MOUNT FITCH NORTH AREA
RADIOMETRIC RESULTS
LEGEND
Ag Rum Jungle Complex
Plr Crater Formation
Plo Coomalie Dolomite
Pla Acacia Gap Tongue
Pld Golden Dyke Formation
Geological boundary
Drill hole with following readings: 700 045(11) 026(23)
700 Alpha reading 700 cpm
045(11) Maximum down-hole gamma reading 0·045 mR/Hr at 11 feet
026(23) Bottom of hole gamma reading 0·026 mR/Hr at 23 feet
Drill hole with alpha reading of 1000 cpm and over
Geology after Miezitis (1967) and Needham (1970)
100 50 0 100 200 300 Metres
400 200 0 400 800 1200 Feet
MOUNT FITCH NORTH PROSPECT
MOUNT FITCH PROSPECT
Plo / Pld
544N 540 536 532 528 524 520 516 512 508 504 500 496 492 488 484 480 476 472 468 464 460 456 452 448 444 440 436 432 428N 426N 422 418N
123E 119 115 111 107 103 99 95E
137E 135 131 127 123 119 115 111 107 103 99 95E
TO ACCOMPANY RECORD 1971/83
D52/87-548

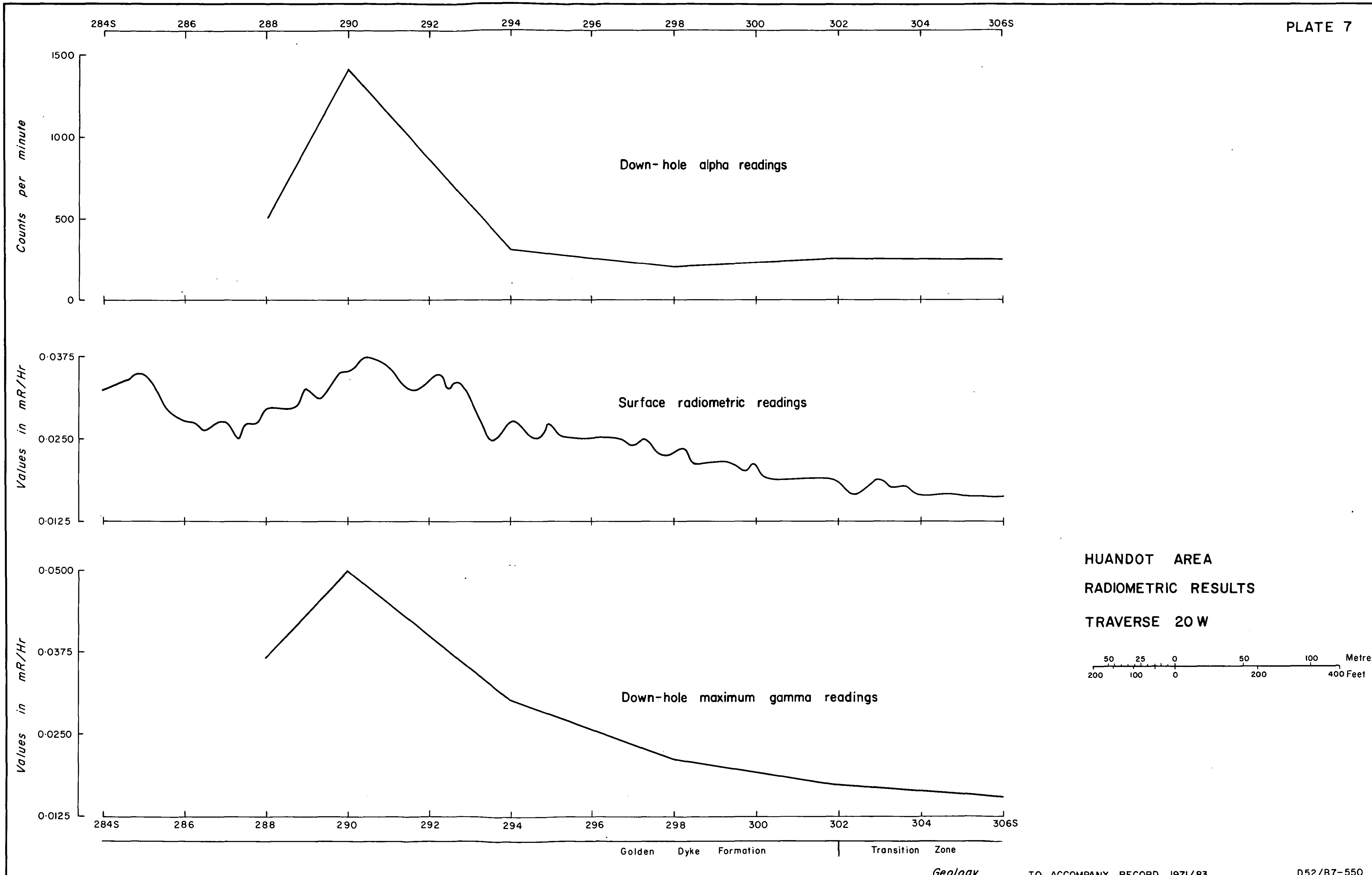
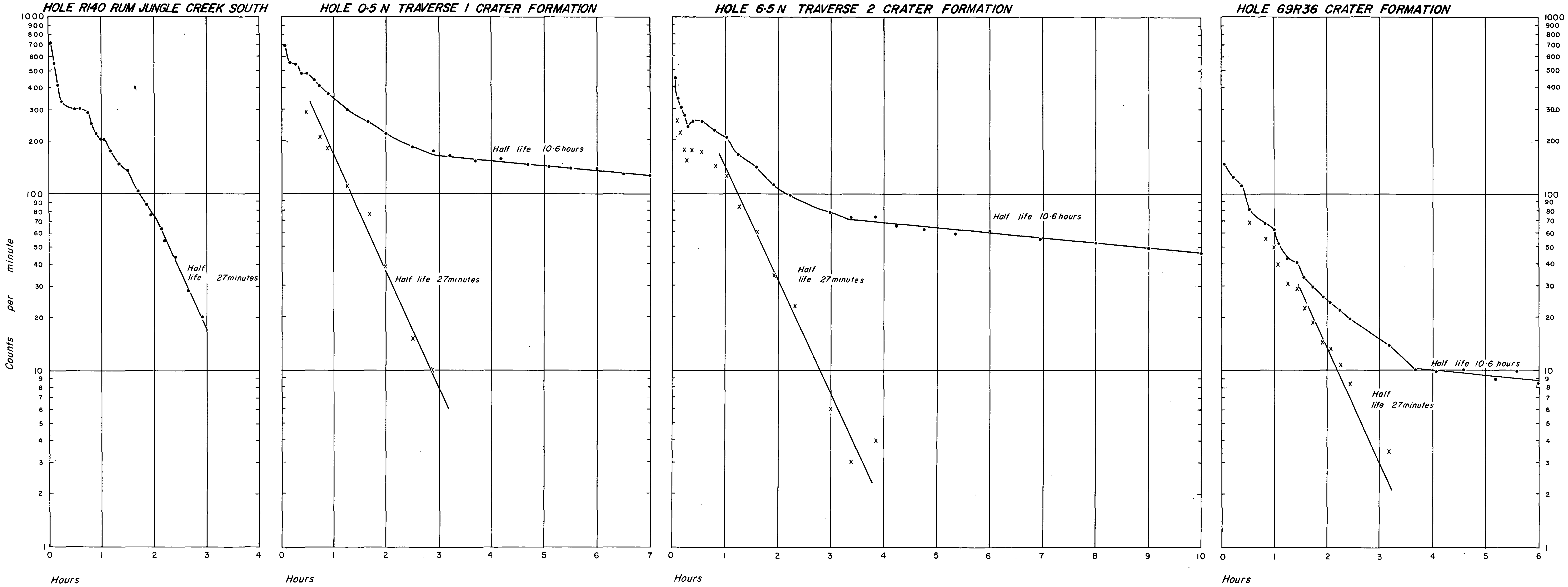


PLATE 7
284S
286
288
290
292
294
296
298
300
302
304
306S
1500
1000
500
0
Counts per minute
Down-hole alpha readings
0·0375
0·0250
0·0125
Values in mR/Hr
Surface radiometric readings
0·0500
0·0375
0·0250
0·0125
Values in mR/Hr
Down-hole maximum gamma readings
Golden Dyke Formation
Transition Zone
HUANDOT AREA
RADIOMETRIC RESULTS
TRAVERSE 20 W
50 25 0 50 100 Metres
200 100 0 200 400 Feet
Geology
TO ACCOMPANY RECORD 1971/83
D52/B7-550



LEGEND

- • Total count rate
- x Total count rate less plot of 10·6 hours half life

COMPARISON OF DECAY CURVES OF ALPHA ACTIVITY FOR SAMPLES FROM THE RUM JUNGLE AREA

TO ACCOMPANY RECORD 1971/83

D52/B7-551

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