BUREAU OF MINERAL RESOURCES
GEOLOGY AND GEOPHYSICS

Report on the Geology of the Williams and Naraku Batholiths

By L. A. I. Wyborn

Minerals and Land Use Program, Professional Opinion

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Summary

This work was prepared on a request to provide field information on the Williams and Naraku Batholiths, which I visited in a series of short field trips in 1978, 1984, 1985, 1986 and 1988. I have only included data on the post D_2 phases. I have included very little information on the Naraku Batholith, primarily because I have not done all that much work on it since my initial sampling trip in 1978.

Five traverses are documented which focus in particular on the altered phases of the Williams Batholith and some albitite intrusions in the Naraku Batholith. My last trip to this area was in 1988, and since then, as there has been a considerable amount of exploration work done in the area, the access information may not be all that reliable. As far as is possible, I have recorded access as it was in my last visit, and I take no responsibility for accuracy, as I have not had the luxury of checking its current status.

The five traverses documented are as follows:

Traverse 1— Wimberu Granite
Traverse 2 — Northern Squirrel Hills and southern Mount Angelay Granite
Traverse 3 — Hampden Mines to northern Mount Angelay Granite and Cloncurry
Traverse 4 — Tank Hole Bore and Glen Eva Homestead area
Traverse 5 — The southwestern plutons of the Williams Batholith

In the accompanying documentation I have provided a preprint of an article on the Williams Batholith from the next issue of the BMR Research Newsletter. It provides an overview of the Williams granite system and in particular refers to the concept of convective fractionation. I suggest that this article, as well as the article on "Granites: their tectonic and metallogenic applications" are mandatory reading before setting foot on any of the localities described in this report. I have also included a copy of the BMR regional radiometrics, as it is invaluable in determining the location of the fractionated phases. It is a hand coloured copy of the original diagram which appeared in the Bulletin on the Duchess-Urandangi Region.

Finally, for anyone attempting to follow though on the traverses described in this area, remember that the Williams and Naraku Batholiths are the most interesting and spectacular batholiths that I have ever worked on. The diversity in primary magmatic phases and the overprinting alteration types is almost unique, and their association with Cu and Au mineralisation in the area is without question.

Lesley Wyborn

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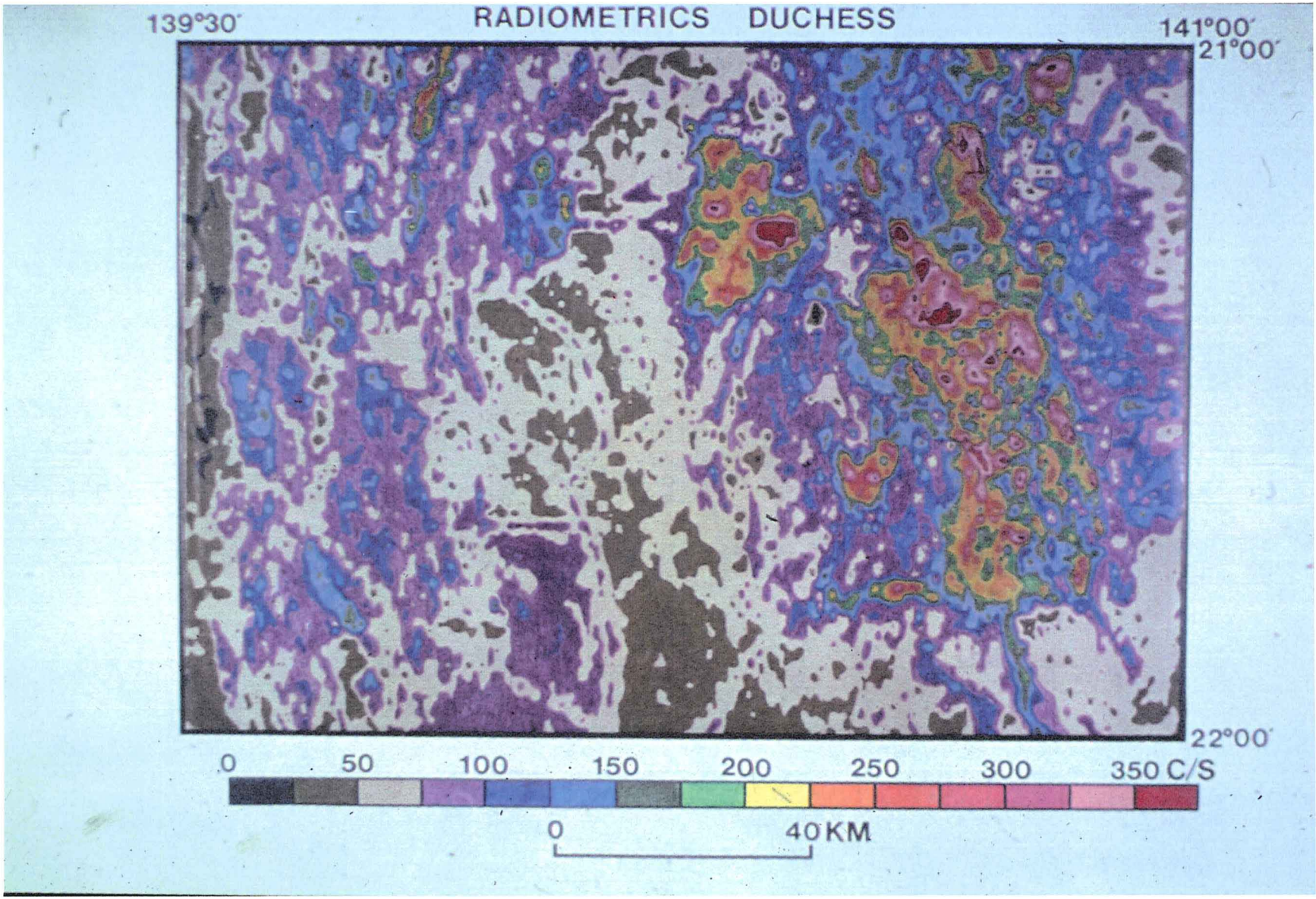
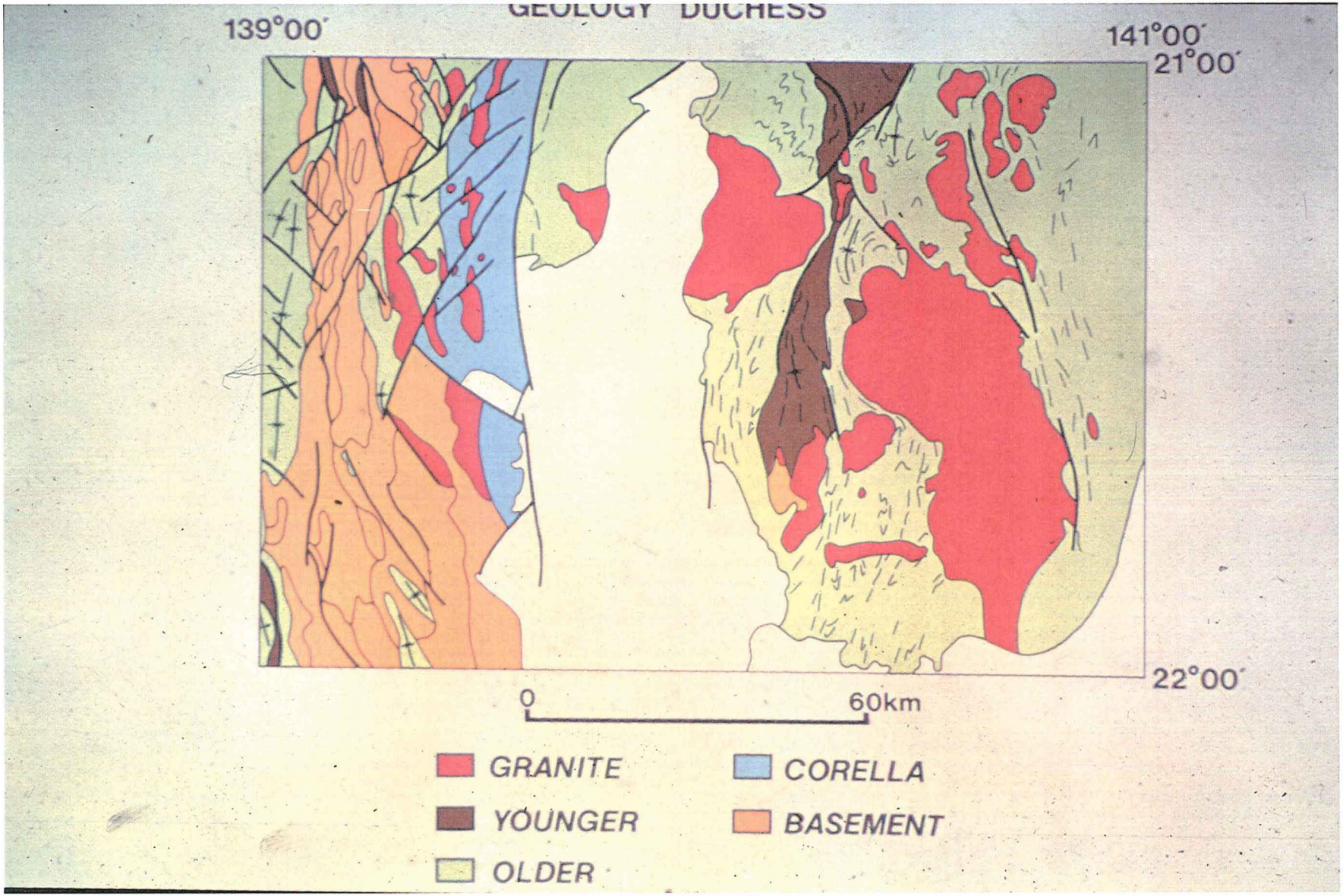


BMR Regional total count radiometrics.

Main rock units on
Duchess 1:250 000 Sheet



Traverse 1: Wimberu Granite:

Overview: The Wimberu Granite is one of the zoned plutons in the Williams Batholith and provides ample evidence for interaction of late granite phases with the early intrusive phases, mineralisation, breccias and massive ironstones. There are many small Cu and Ag prospects and mines within and around the margins of this pluton. All mineral occurrences that I visited within the granite were at the intersection of the late fractionated granite phases with the early more mafic magnetite-bearing granite types.

The traverse will be divided into four parts:

Part 1. Florence Bore SSW to Cloncurry River

Part 2. North Side of Cloncurry River to fractionated core

Part 3. Along Cloncurry River to Camel Bore

Part 4. Agate Downs - Young Australia Cu Mine - Silver Phantom Ag Mine.

Wimberu Granite Part 1.
Florence Bore SSW to Cloncurry River

Overview: I have done this traverse three times and each time I have found something different. Although the rock types are diverse, my interpretation is that there are two interacting granite phases here, an early more mafic magnetite-hornblende-biotite granite and a later more fractionated high U phase which contains hematite.

General Access: Whenever I went along the track from Florence Bore (GR MALBON 350585), I used to make a courtesy call at Brightlands Homestead GR MALBON 255695. They were friendly people, although their attitude was that the granite country was useless — "not even the cattle go there". Each time I did this track (1984, 1985, 1988) it was harder and harder to find - in many places all you will be following is two small ridges of dirt pushed up be a grader. If you can find the track to make the trip it is well worth it. The track is fairly essential to get through some cliffy bits at GR MALBON 315532

Locality 1 — Felsic marginal phase, and D_3 foliation in an early magnetite-bearing granite

Introduction: The aim of visiting this locality was to investigate the cause of the EW lineaments GR MALBON 335542 and also the composition of the marginal phases of the granite.

Sample sites:

Sample Number	1:100 000 Map Sheet	Grid Reference
85206000	MALBON	337542
85206001	MALBON	335542

Access: This site is near the edge of the granite. From memory we left the track at GR MALBON 332547 and drove around the base of the hills.

Geology: The EW lineaments are associated with some felsic granite which appears to be a small pod near the margin of the granite. It contains no opaques and is not as finer grained as some of the other felsic derivatives. This leucogranite is chemically fairly bland and is not enriched in the fractionating elements (Rb, U etc) as say the core phase or the late stage granite dykes and aplites.

The more coarse grained samples adjacent to this leucogranite are typical of the early crystallising phases: they contains coarse hornblende, magnetite and titanite and are fairly high in Ba, but low in Rb and U relative to the later granite phases. At one locality (GR MALBON 335542) I recorded a foliation of 210^{o}. This is not a marginal primary flow foliation, as it does not run parallel to the boundary of the granite. However, I interpret the development of this foliation as occurring late in the history of the granite,

prior to final crystallisation. Despite their alignment, the biotites in this sample are coarse grained "igneous" biotites, not decussate aggregates. In other areas I have seen where the granites have been affected by late shearing (e.g. Pine Creek, Kosciusko), the granites have a cataclastic texture, and the biotites are usually decussate aggregates formed along fracture zones within the granite and trending parallel to the main foliation.

Comment: "Bland" leucogranites are common around the margins of fractionating granites and represent small pockets of melt derived at an early-intermediate stage of crystallisation from the melt. Because they are derived at an early stage, they are not all that important in metallogeny as firstly they do not concentrate metallic elements, and secondly, their oxidation state does not contrast strongly enough with the early formed phases. The EW lineaments are intriguing as the more felsic core and late aplites have different strike/joint/lineament directions. Titanite is always common in the Williams Batholith. It is often deep red, with many fine black inclusions which have been interpreted to be uraninite.

The "shear" zone recorded in the coarse grained sample is on strike with some major lineaments to the southwest near GR MALBON 310518 which are causes by dyking of aplites. The shear zone is also on line with some fault zones recorded in the Mitakoodi Quartzite to the NW near the Green Valley Cu prospect (GR MALBON 375604). There are also several other Cu prospects in the Mitakoodi Quartzite to the north of this pluton near NNW trending faults. NNW/NNE trending faults are supposed to be indicative of D_3: therefore this site is one of those that has convinced me that D_3 is syn to late the intrusion of the granite.

Locality 2 — Breccia Zone within the granite

Introduction: This site is an example of a breccia zone within the granite. I went there to investigate a fairly strong NNW lineament on the airphoto on top of the hill.

Sample Sites:

Sample Number	1:100 000 Map Sheet	Grid Reference
88206006	MALBON	316545
88206007	MALBON	316545
88206008	MALBON	316545

Access: We drove cross country to the west of the road, and I think that we came around the south side of the hill. I am not very sure of this.

Geology: The granite clasts at this locality is completely altered to sericite/muscovite, all Fe is as Fe_2O_3 and the sample contains 6.39 wt% K_2O and 12.1 ppb Au. The Y value at 311 ppm is 3 times the next highest value in the WIlliams Batholith. The hematite matrix to this breccia contains high Ba (2696 ppm).

Comment: The unusual amounts of Y in this sample reflects the capacity of the alteration to

mobilise elements that are supposedly stable in alteration. The high Au value is also probably related to alteration rather than to a high primary value.

Locality 3 — Hematite "dykes", Cu prospects, late stage granite intrusions.

Introduction: This area is the focus of an anomalously high area in the BMR regional total count radiometrics. It is also the site of some Cu prospects. I have included two photographs of the breccias at 88206009.

Sample Sites:

Sample Number	1:100 000 Map Sheet	Grid Reference
84536110	MALBON	307529
88206009	MALBON	309525
88206010	MALBON	309525
88206011	MALBON	309525
85206002	MALBON	303525

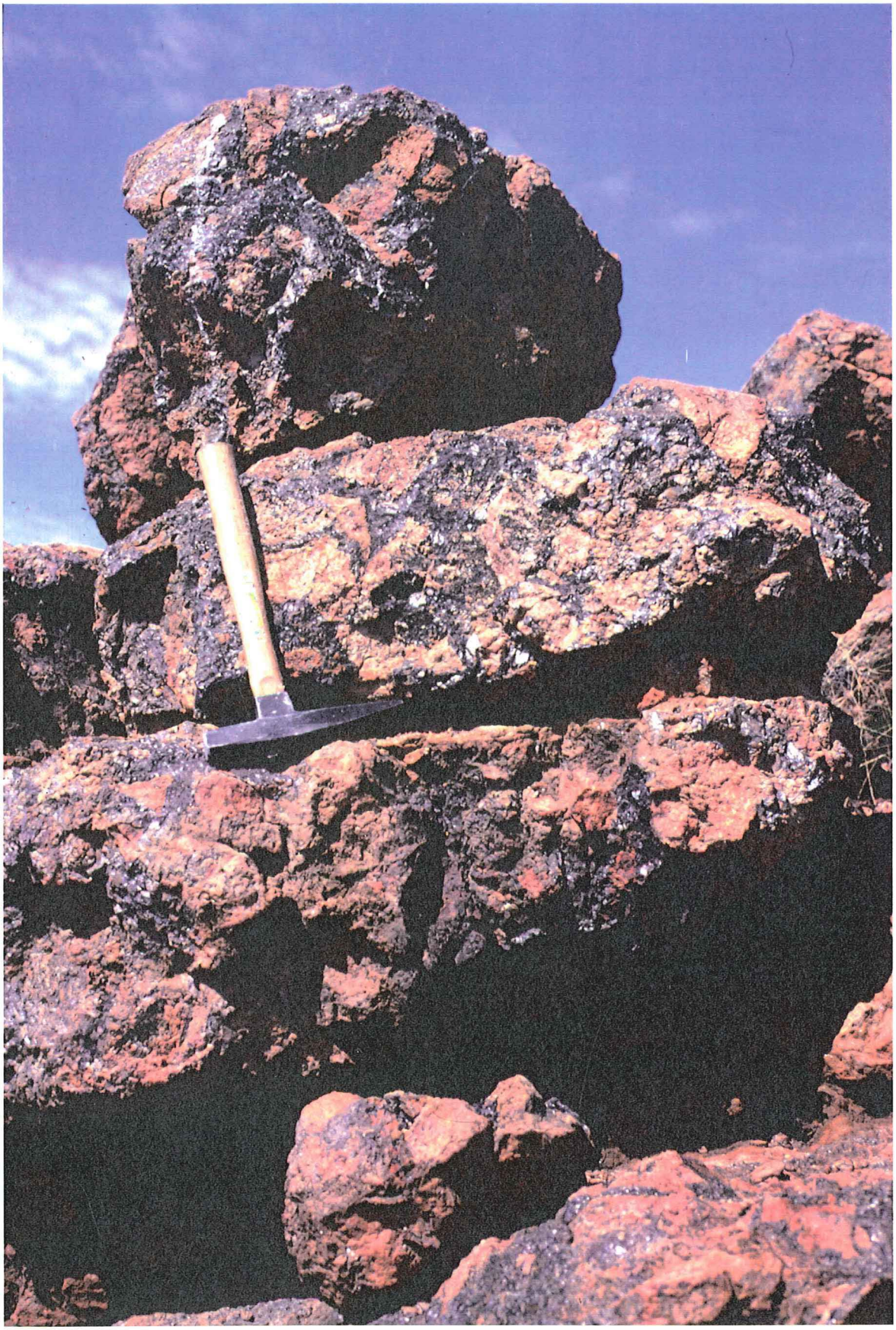
Access: Keep following the track, although it is now almost impossible to find. The road goes right beside some costeans which you cannot miss.

Geology: This area is rather spectacular for the elongate "dykes" of hematite, which appear to occur at the intersection some early coarse grained granite with late stage aplite dykes. Some coarse grained granite was sampled at GR MALBON 307529 adjacent to one of the Cu costeans. This granite was altered and contain the skarn-like titanite-clinopyroxene assemblage. As is typical of the "skarn" type the granite is white, low in Ba and Rb and high in Na_2O. The Fe_2O_3/FeO is not as high as in the more brick-red potassic altered granites.

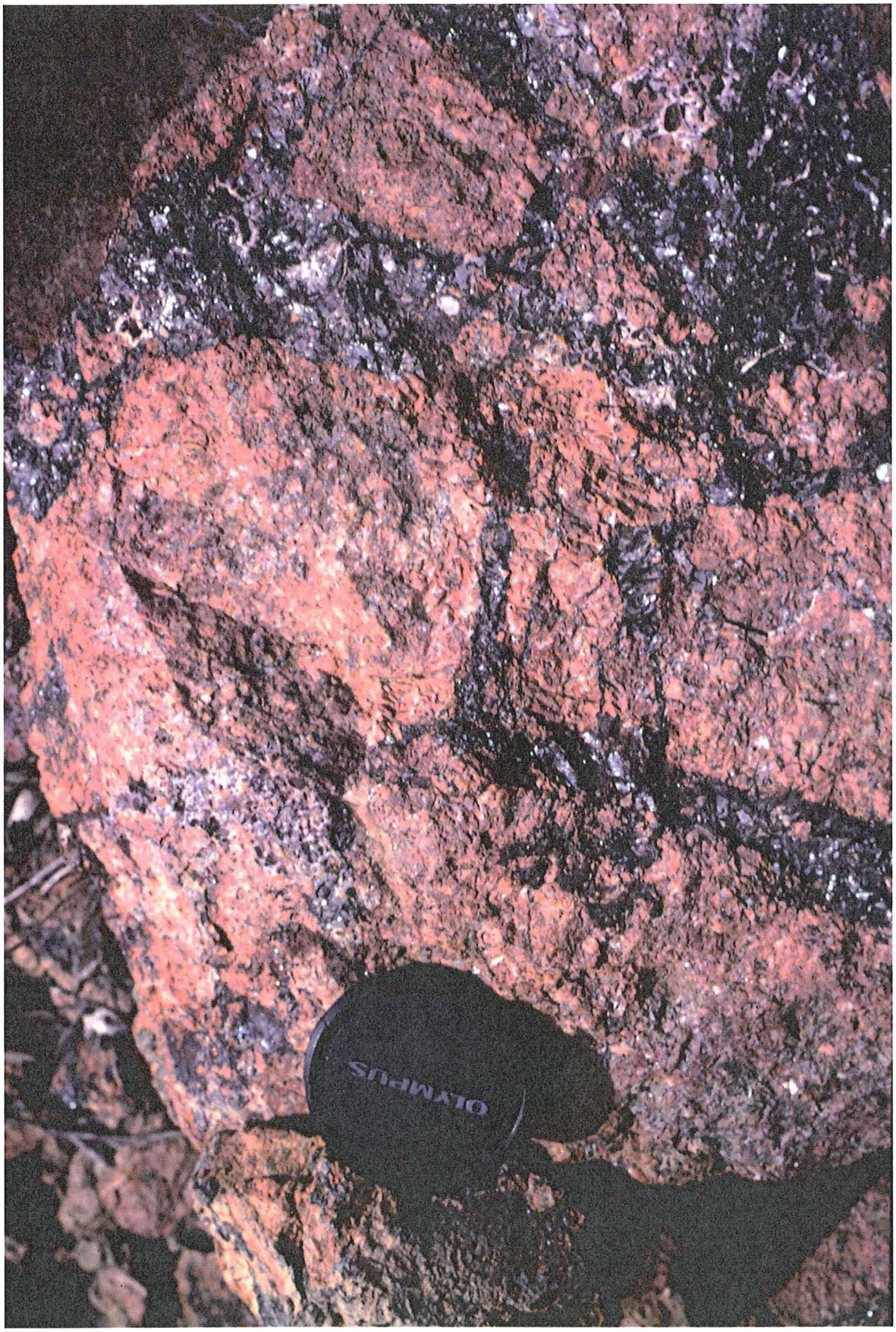
Two samples were collected at an old Cu prospect which was in a breccia zone trending 240°: they included a fine to medium grained granite clast from the breccia and the hematite-rich breccia matrix. The hematite matrix contained 24089 ppm Cu and 30.5 ppb Au, whilst the granite clast contained 3809 ppm Cu and 17.7 ppb Au. This granite fragment, although altered is high in Rb (330 ppm), U (29 ppm), Y (102 ppm) and P_2O_5 (0.24 wt%). Some of the breccias contained tourmaline. Nearby the granite is massive, coarse grained and magnetite-bearing.

An aplite was collected at GR MALBON 309525 and contains very low levels of elements such as Rb, U and Y, which are taken to indicate fractionation. This can be typical of aplites.

Comment: I interpret the high U value in the granite clast as primary as the Th value is high 58 ppm, and suspect that this is a sample of late fractionated hematite-bearing granite which has intruded the older more magnetite bearing granite. The hematite dykes possibly represents the end product of interaction between the two granite types. In contrast to other localities in the Williams Batholith, there has not been pervasive



Breccias at site
8620 6009



Breccias at site
86206009

brecciation, rather the hematite has concentrated along the interface with minor brecciation. There is also a highly jointed area of fine to medium grained leucogranite at GR MALBON 293528, which was too weathered to sample. If you find any fresh stuff I would love a piece of it.

Locality 4 — An area of mafic and felsic dykes

Introduction: This site was selected because of the strong lineaments clearly visible on the air photos around GR MALBON 305515 trending 210°, which is supposed to be the D_3 direction.

Sample Sites:

Sample Number	1:100 000 Map Sheet	Grid Reference
85206003	MALBON	304518
85206004	MALBON	304518

Access: By this stage, I think we had lost the track and were just heading cross country.

Geology: I did not take many samples, but the area was riddled with aplite dykes all trending 210°, and some mafic dykes. I sampled one mafic dyke at GR MALBON 304518 to the east of another copper prospect. The dykes are hornblende + plagioclase whilst the granite is hornblende+ biotite+titanite + magnetite. The mafic dyke contains 85ppm Cu. The granite is not particularly fractionated and is low in U and Rb.

To the south, in a costean at the Cu prospect at GR MALBON 302458, there is yet another hematite band occurring at the intersection of coarse granite and aplite and there is veining into the granite.

Comment: This area is a complex one with interaction of late phases of the granite (fractionated granite, aplite) intruding earlier granite phases. Almost all Cu shows that I visited were at the intersection of the late and early granite phases. From the radiometrics it is obvious that there is a fairly substantial volume of late fractionated granite in this area. Note that the late dykes are generally trending 210° — a direction generally accepted as consistent with D_3. This locality also helps to confirm that the granite is post D_2, but pre-(early granite phases) and syn-D_3(late fractionated dykes, aplites and leucogranites.

Wimberu Granite Part 2
North Side of Cloncurry River to fractionated core

Locality 5 — Fractionated core of the Wimberu Granite

Introduction: On the 1:100 000 geological map a core of highly jointed non-porphyritic biotite granite has been differentiated. On the BMR regional total count radiometrics this is distinguished as one of the higher anomalous areas. Due to an accident whilst sampling (an enormous boulder dropped on my foot while we were using the feathers and wedges), we were unable to spend as much time as I would have liked, and there is possibly more to be gained from this site, particularly along the junction of the felsic core and the coarser grained granite. I record in my notebook a kaolinised and Cu stained vein at GR MALBON 353457.

Sample sites:

Sample Number	1:100 000 Map Sheet	Grid Reference
85206007	MALBON	339454
85206006	MALBON	355457
85206005	MALBON	355457

Access: I last visited in 1985. We followed a feint track along the north side of the Cloncurry River to GR MALBON 334449, and then bush bashed up the creek to the core.

Geology: The core is quite distinctive on the air photographs and is highly jointed and veined. The core is composed of hematite-bearing fractionated granite, which in one sample, contained 30 ppm U. The other core sample had 37 ppm Cu and 5.5 ppb Au. The core is intrusive into the earlier coarse grained granite, which at locality GR MALBON 339454 contains magnetite and small grains of chalcopyrite in thin section. This sample, although located 1km west of the core, is altered and contains some late quartz and feldspar veins.

Comment: Unfortunately, I only sampled the margins of this core, but again there appears to be interaction between the core (late fractionation phase from the granite) and the outer coarse grained granite phase (earlier coarse grained magnetite bearing phase).

Wimberu Granite Part 3
Along Cloncurry River to Camel Bore

General Access: With difficulty in 1984 we crossed the Cloncurry River and with ease we crossed it in 1985 — it definitely depends on where you pick your spot as the original crossing is washed out. If you can get across, proceed along the road to the south east to Camel Bore. If not, you have to go back to Florence Bore and then come around the top to the Young Australia. If you come this way, do part 4 first.

Locality 6 — Area to the north and west of Camel Bore - examples of K- and Na-rich alteration and granite brecciation.

Introduction: I was attracted to this area because of the regional BMR total count radiometrics, this shows up as a high anomaly, plus the BMR airphoto overlays mentioned granites with pegmatite, Fe-rich granite, mixed granites and sediments.

Sample Sites:

Sample Number	1:100 000 Map Sheet	Grid Reference
86206071	MALBON	341392
86206072	MALBON	341392
86206073	MALBON	341392
86206074	MALBON	315388
86206075	MALBON	316384
86206076	MALBON	316384
86206077	MALBON	315385

Access: I last visited the site in 1986. Access was from Agate Downs to Camel Bore, and thence cross country. The field hand drove the car to every sample site, including those on top of the hill (I walked): all samples were collected using a drill.

Geology: **Site 1** is located approximately 300m west of the road from Camel Bore to Dry Paddock Bore at around GR MALBON 341392. At this site there is an aplite dyke associated with hematite granite breccias. This site is analogous to locality 3, only here instead of having major hematite dykes at the junction of the aplite and the granite, the granite is red, strongly brecciated, with a hematite-rich matrix. The granite is coarse grained, silicified and hematised, whilst the hematite-rich matrix has 2865 ppm Ba. The samples have 10.63 and 7.34 wt% K_2O and 0.13 and 0.17 wt% Na_2O with low Au and Cu. The related aplite dyke contains hematite, high Nb, U (120 ppm), and low Ba suggesting that it is a late fractionating phase from the granite.

Site 2 is located 2kms cross country, WNW of Camel Bore at around GR MALBON

315388. Four samples were collected from here, and 3 are up on the ridge top. The granite phases present in this area are complex and in contrast to site 1, are white, dominated by sodic alteration, with Na_2O between 4.7 to 7.12 wt % and K_2O between 0.76 and 0.89 wt%. The samples contain clinopyroxene and titanite (which is visible in hand specimen): the minor opaque phases present are hematite. P_2O_5 is high in one specimen (0.32 wt%). Thorium (110 ppm), U (up to 22 ppm) and Cu (32 ppm) are high in these localities; Ba is low.

Comment: Both of these sites are dominated by alteration, which could well be pervasive throughout this region. Site 1 is dominated by K alteration: site 2 by Na alteration. The radiometric anomaly could reflect the high U of the granite. Site 2 is also located near several Cu mines including Mount Agate, Saddle Ridge North, Saddle Ridge, and Horse Creek (40.4 tonnes Cu) which are hosted in Argylla Formation or Marraba Volcanics, both highly magnetic units.

Wimberu Granite Part 4
Agate Downs - Young Australia Cu Mine - Silver Phantom Ag Mine.

General Access: There used to be a good crossing at Agate Downs homestead which was abandoned when I last visited in 1988. Proceed past Young Australia (which is worth a visit if you have time, even if it is in the country rock and not granite !).

Locality 7 — Silver Phantom Silver Mine — an example of mineralisation at the intersection of two granite types.

Introduction: A new operation at the Silver Phantom Mine was established here by Ginger Walton (son of Clem Walton who discovered Mary Kathleen Uranium mine) in 1985. Ginger and his son had a small operation going here chemically extracting the silver in above ground swimming pools. However, when I last called in 1986, things were not going too well: recovery rates were poor and Ginger's son had made himself a paraplegic in an explosives accident in the hills beyond the mine, whilst looking for potential mineralisation sites at the junction of fine grained granite with coarse granite (I wonder who pointed it out to them).

Sample Sites:

Sample Number	1:100 000 Map Sheet	Grid Reference
85206010	MALBON	377425
85206011	MALBON	377425

Access: I last visited here in 1986. There used to be "Silver Phantom" and "Walton" signs at the junction of the track in with the road to the Young Australia mine. The entrance I seem to recall is hidden in some trees/bushes.

Geology: Two samples were collected close to the mine: a coarse grained granite and a fine grained granite. Although altered, the mine itself occurs at the junction of the coarse magnetite bearing granite and the fine grained hematite-bearing granite. The ore is in barite and a jasper like-rock and exposures of the Mitakoodi Quartzite is nearby.

Comment: Again we have mineralisation at the intersection of a coarse magnetite-bearing granite and a fine hematite-bearing granite. I have not mapped out all of the phases in this area. In the vicinity of this mine there are several other small shows including Young Australia (3916 tonnes Cu), Hidden Treasure (22.8 tonnes Cu), Mount Devoncourt (32.5 Cu), Silver Spur (?) and Silver Phantom (4453.2 kg Ag). The first two deposits

are hosted in Answer Slate (which contains some carbonaceous units), whilst the last three deposits are within granite.

The coarse grained granite sample has quartz, plagioclase, K-feldspar, magnetite, titanite, hornblende and biotite. Relative to other Wimberu samples, the coarse sample has high Ba (1655 ppm), La, Ce, and 18 ppb Au, The fine sample has quartz, feldspar and hematite and 1 ppb Au. I interpret the mineralisation as resulting from the intrusion of the late more oxidised hematite bearing fine grained granite into the earlier high Ba coarse magnetite-bearing granite: the Ba in the gangue was probably mobilised from it.

Traverse 2 - Northern Squirrel Hills Granite and Southern Mount Angelay Granite.

Overview: This traverse shows more on the alteration of the granite batholith. I focussed on this are because the BMR regional total count radiometrics shows a strong regional high in this area centered around GR MOUNT ANGELAY 630370. Unfortunately access prevented getting into this region, and I assume that I went around the periphery of this anomaly. If it is analogous to the core of the Wimberu Granite, then I went around the more interesting parts anyway, i.e. the parts where the more felsic differentiated parts intrude the earlier granites.

General access: From the Silver Phantom Mine, take the road along the north side of the Cloncurry River. There is a fascinating gate post along the way. Cross the Selwyn Road and head for Farley Homestead. I made a courtesy call at Farley Homestead GR MOUNT ANGELAY 479372 for permission to enter the area. I'm not sure how much land he owns on this traverse, but the owner was very amenable to geologists. He also remembered some company drilling for Cu up to the north of granite — in the unit labeled Pkr_g, possibly the drill holes around GR MOUNT ANGELAY 560425.

I last visited in 1988 and the track was deteriorating from when I had made my first trip in 1986.

Locality 1 — Sulphide rich granite at the edge of the Farley Pluton

Introduction: This site is north western margin of a pluton, which I have informally named the Farley Pluton. The pluton covers the area marked as $Pgis_p$ north of the Cloncurry River and west of the big area of Pgis. In contrast to the typical red colour for the magnetite bearing phases or the white colour of the skarn bearing phases of the Williams Batholith, the Farley pluton is green and contains sulphide. It is also extensively veined by late stage granite veins. To the north of the pluton is an area of distinctive Kuridala Formation marked as Pkr_g which contains metagreywacke, meta-arenite, quartzite, mica schist; minor breccia and banded ironstone. This area of Pkr_g also has several small plutons of granite intruding it, as well as some copper prospects.

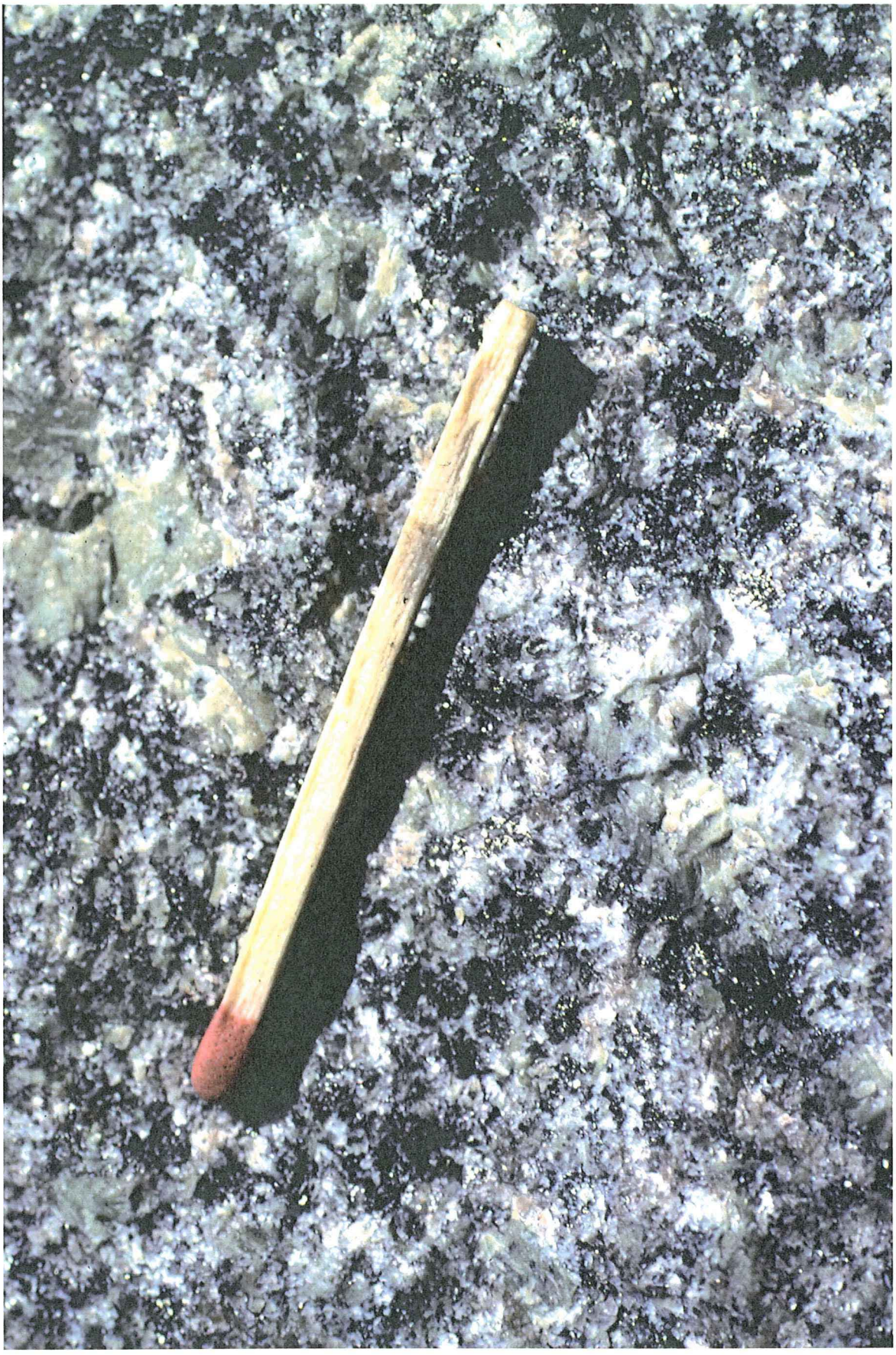
Sample Sites:

Sample Number	1:100 000 Map Sheet	Grid Reference
86206045	MOUNT ANGELAY	500397
86206046	MOUNT ANGELAY	500397

Access: Take the turn off to Farley homestead from the Selwyn Road GR MOUNT ANGELAY 474372, and then the turn off to a bore just over 2 kms from the homestead. The best locality is one Km along this track, on a small knob to the west of the track. NB. Follow this track back to the next locality which is on the road to Mount Tracey Homestead.

Geology: This site is fairly typical of the sulphide rich granite. Note the green colour (see photograph). One sample 86206045 was collected at the margin, whilst 86206046 was collected 50 m to the north. Some samples are quite sulphide rich, although it is mostly pyrite with some chalcopyrite. There is still abundant magnetite in these samples and they have quite high susceptibilities. These sulphide-bearing phases are not any more enriched in Cu (37 ppm) or Au, relative to the magnetite bearing samples although the marginal sample has 39 ppm U.

Comment: The green colour only occurs where one granite intrudes reduced sediments. That this whole pluton is green which may mean that the level of exposure is close to the roof zone, at that all the late stage granite dykes reflect concentration of late fluids in the roof area as is evidenced by all of the late granite veins intruding the granite. I also speculate that in the area to the north the sediments are not all that thick. I assume that this is an early pluton and that the later stage magmatic processes may be extracting Cu from the already crystallised granite. That the sulphide bearing phases are not compositionally distinct from the magnetite bearing samples suggests that the sulphur may have existed in the primary magma and that local reduction with the carbonaceous has allowed the crystallisation of some sulphide.



green sulphide rich granite
from Locality 1.

Locality 2 — dyke systems within Farley pluton, plus a more fractionated core.

Introduction: In this area the granite is extensively intruded by aplite and hornblende-bearing granite dykes. The granite is also more fractionated than the mafic granite at the margins

Sample Sites:

Sample Number	1:100 000 Map Sheet	Grid Reference
86206051	MOUNT ANGELAY	520365
86206052	MOUNT ANGELAY	549355

Access: Along the track to Mount Tracey Homestead, site 1 is a nondescript outcrop on south side of road at GR MOUNT ANGELAY 520365; site 2 is at GR MOUNT ANGELAY 549355.

Geology: **Site 1:** The sample of the dyke contains some sulphide, hornblende and magnetite. Geochemically there is nothing special about these dykes; they are not particularly fractionated and unlike the Wimberu Granite, there appears to be little reaction between the dykes and the granite host.

Site 2: This is a more felsic version of the granite

Comment: These sites show that the Farley pluton is fractionating, but they is little interaction between the types. The dykes, like the granite, are sulphide bearing and hence are not markedly contrasting to the granite. I think that this explains why there is little reaction between the two types. This granite is also fractionating towards the east, and may have originally been a concentrically zoned pluton, with the eastern half chopped of by the intrusion of Pgis. The granitic dykes appear to align in a circular fashion as well, suggesting that they may be ring dykes.

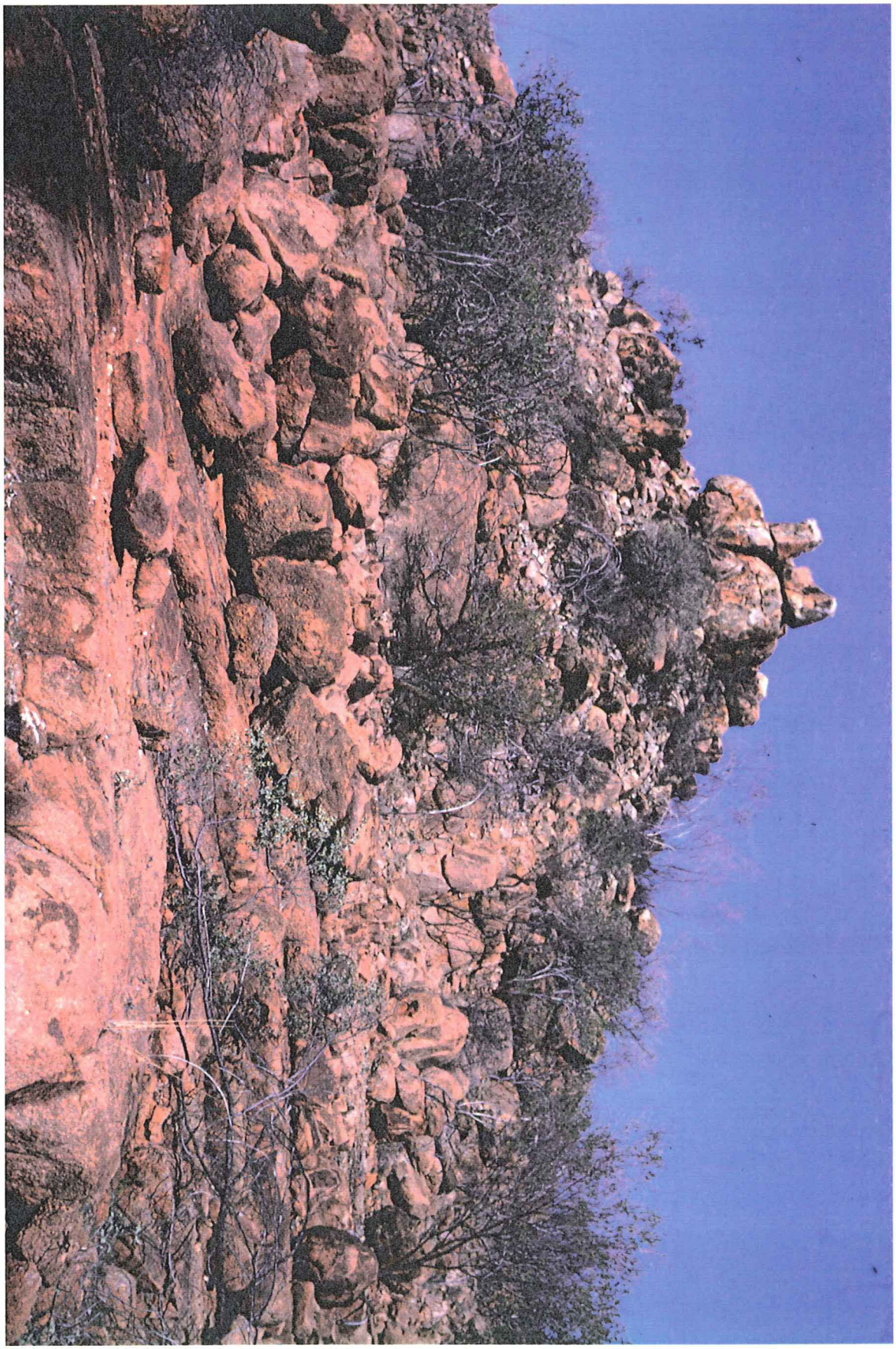
Locality 3 — Policeman's soak breccia pipe of Corella—like rocks within granite.

Introduction: This locality should be a geological monument. It is a breccia pipe within the granite of predominantly Corella Formation. I have included a photograph of the pinnacle.

Sample Sites:

Sample Number	1:100 000 Map Sheet	Grid Reference
86206056	MOUNT ANGELAY	688301
86206057	MOUNT ANGELAY	688301
86206058	MOUNT ANGELAY	688301
86206059	MOUNT ANGELAY	688302

Access: The track is confusing: don't end up going up Anvil Creek. The actual road to



Locality 3 - Breccia Pinnacle
at Policeman's Soak

Policeman's Soak runs along the south side of the Cloncurry River. Policeman's Soak is a bore and tank, just to the east of it is a little pinnacle of breccia.

Geology: Walk around this locality: it is very diverse. The breccia contains rounded fragments of calc-silicates and some rare rounded fragments of granite. My photo of this granite fragment is missing so if any one would volunteer to replace it I would be grateful. The granite in this area is typical magnetite-hornblende-titanite, although there are some fine grained phases.

Comment: My only explanation for this breccia body is that it is an implosion structure in which fragments of Corella Formation and the granite have fallen back in. The other alternative is that it is a pipe of calc-silicates extruding though the granite. The finding of granite fragments in this locality confirms that much of the Corella Breccias are formed at the same time as the intrusion of the granite.

Locality 4 — Mick and Jim's Well — potassic and sodic alteration in the extreme

Introduction: Another geological monument — well worth the effort of visiting. There is a large herd of wild camels around here so watch out !!!

Sample Sites:

Sample Number	1:100 000 Map Sheet	Grid Reference
86206063	MOUNT ANGELAY	726397
86206064	MOUNT ANGELAY	726397
86206065	MOUNT ANGELAY	723407
86206062	MOUNT ANGELAY	718412
86206060	MOUNT ANGELAY	717412
86206061	MOUNT ANGELAY	717412

Access: Follow the road from Policeman's Soak across the Cloncurry River, at GR 732328 head north to significant bend in road. (The other road is the original horse coach road to the Hampden Mines form Cloncurry, and it is possible to get through here to Cloncurry, but remember, unless it has been improved, it was designed for horses !!!).

Continue on to Mick and Jim's Well, the best potassic alteration is on the knob to the west of the well.

Geology: In this area there is evidence of abundant alteration, with rapid shifts from potassic to sodic alteration.

Site 1: is a rocky knob just west of the well (GR MOUNT ANGELAY 726397) and is dominated by potassic alteration. This is what I call red rock potassic alteration. The rocks are characterised by high K_2O, no Na_2O, and high Ba (2291 ppm) — the Au values from this area are all low. If you can find it, on the north side of the hill there is an extremely altered, banded hematite rich rock (see photograph on the next page).

Banded red rock alteration at locality 4

This banded rock has been interpreted as a fragment of Overhang Jaspillite. I disagree with this interpretation and think that it is alteration in the extreme. I have seen a similar sample to this from the Olympic Dam deposit.

Site 2: is in the north side of a small creek bed GR MOUNT ANGELAY 723407. It is not crucial to find the outcrop, but the granite in this area is a skarn type granite (clinopyroxene- titanite) with fairly normal granite although it has slightly higher Na_2O.

Site 3: if you can find it is at GR MOUNT ANGELAY 717412. From memory it is across the creek in some bushes. Side by side there are potassic and sodic altered granites with one, brick-red in colour having 16 wt% K_2O and 0.14 wt% Na_2O, the other, being pure white, with 8.62 wt% Na_2O and 0.74 wt% K_2O.

Site 4: By the side of the road at GR718412. This is an extremely weathered sample which has retained its uranium. I just sampled it to contrast the modern weathering with the ancient Mesozoic (?) weathering, in which uranium is leached out.

Comment: This locality illustrates some of the diverse alteration types and how rapidly they change. The really deep red colour is characteristic of the late potassic alteration, and I believe that it overprints the sodic alteration. There is also an early potassic alteration, but I haven't located it at this site. The change between the two alteration types is knife-edge: there is no gradational boundary.

Traverse 3 — Hampden Mines through to northern Mount Angelay Granite to Cloncurry

Overview: This is a fairly good road though to Cloncurry and the aim of this traverse is to examine fractionated granites, brecciation and K and Na rich metasomatism. If you check the radiometrics, you can see that the granite in this part of the northern Mount Angelay sheet area is quite high in total counts.

General Access: I last traveled this road in 1988, and it was fairly good and easy to find. It leaves the main Selwyn road at GR MOUNT ANGELAY 482456. Follow the track to the east from near the old mine: it's never been hard to find.

Locality 1 — Very fractionated part of the Squirrel Hills Granite

Introduction: Like all very fractionated parts of the Williams Batholith, this shows up not only as a high on the BMR regional total radiometric count, a highly jointed pattern on the air photographs, but also an area of dense lineaments on the geological map. Some granite veins are shown to the north west on the map: I believe that there are many more than are shown and that this pluton extends under the area to the north.

Sample Sites:

Sample Number	1:100 000 Map Sheet	Grid Reference
86206078	MOUNT ANGELAY	534492
86206079	MOUNT ANGELAY	544495
86206080	MOUNT ANGELAY	539494

Access: Just follow the road, it clips the granite — you can't miss them.

Geology: The granite in these parts is very fractionated, and contains fluorite. There is some pyrite visible in 86206078 and 86206079, which has inclusions of chalcopyrite. Most of the sulphide grains are rimed by hematite. If you walk up the creek on which sample 86206078 exists, you may find a sulphide rich vein, which I recorded in my field notebook. The samples 86206078 and 86206079 both contain about 30 ppm Cu, which is unusual for such fractionated granite.

Comment: The high Cu in these fractionated samples suggests that Cu is concentrating in the late stage phases of the granite. Note the abundant Cu prospects in the vicinity. The largest, Straight Eight, contained 22.6 tonnes Cu.

Locality 2 — overprinting alteration in the Mount Angelay granite.

Introduction: This site gives a tentative chronology of the various alteration types in the granite. I found this when I was heading for fairly massive outcrops which show up on the air photographs. On the way out from this locality I also sampled another red rock/albite pair at GR MOUNT ANGELAY 675505.

Sample Sites:

Sample Number	1:100 000 Map Sheet	Grid Reference
88206014	MOUNT ANGELAY	679511
88206015	MOUNT ANGELAY	679511
88206016	MOUNT ANGELAY	679511
88206017	MOUNT ANGELAY	679511
88206018	MOUNT ANGELAY	678508

Access: Follow the road to Eureka Homestead, which was abandoned when I last visited in

1988. On the way, the road crosses though Corella Breccia. Many times I stopped and walked into the Breccia and I never took very much time to find evidence of an intrusive albitite pipe or albitite veining. The actual sample site is off the road to the Mount Kalkadoon Cu prospect (40.1 tonnes Cu). This road turns south east from Eureka Homestead. At a major creek crossing at GR MOUNT ANGELAY 675502 turn north and head cross county along the west (?) side of the creek to a small gorge.

Geology: At this site there is a small albitite pipe intruding a potassic-altered granite: I have enclosed a photograph on the next page — rock drill and sample bags are for scale. The albitite is cross cut by an even later K-enriched "red-rock alteration. The early potassic alteration is only light pink in colour, and the samples contains 7.04 wt% K_2O and 3.67 wt% Na_2O. The albitite contains 0.20 wt% K_2O and 7.74 wt % Na_2O, whilst the late red-rock alteration contains 13.07 wt% K_2O and 1.79 wt% Na_2O and 1539 ppm Ba. The boundaries between all alteration types is very sharp and all types contain hematite.

Comment: This locality gives a good insight to the nature of the alteration types. As a rule of thumb, the bright red alteration is potassic, and the white style of alteration is sodic. Both contain hematite, but the difference in the colour is a function of the ability of K-feldspar, but not albite to accommodate hematite within its crystal lattice. The late, deep red alteration also inevitably contains very high Ba, whilst the medium to deep pink rocks are have normal Ba values. The albitic alteration is always depleted in Rb and Ba. There are exceptions to the rule, but 90% of the time, the white rocks are albitic, 80% of the time the brick red rocks are K-feldspar, 75% of the time, the medium to deep pink altered rocks are K-feldspar.

One other feature of the alteration is that U does not appear to be excessively mobile. Some U is lost in the alteration and the values are usually half to one third what would be expected from predicted primary igneous Th/U ratios. In fact in the whole Williams Batholith, the only really dramatic loss of U, such as is present in the alteration zones around the Coronation Hill deposits, is found in the ancient highly oxidised Mesozoic (?) regolith profiles developed in the granite, particularly in the southern Selwyn Sheet area. For the most part the modern regolith profile is not leaching uranium. This may therefore mean that any mineralisation associated with the Williams system is likely to be Cu and Au bearing, and with a bit of luck, will not contain much U.

Locality 3 — small albitite pipe in granite.

Introduction: There are many of these albitite pipes within the granite in this area.: in contrast, I have not recoded any in the Wimberu Granite. The next photograph tries to show what they look like — small whitish resistant plugs sticking up in the local granite. They are sometimes stained black. I have selected this one (if you can find it) as it is pure white,

White albitite pipe and potassic alteration at locality 3.

Typical pinnacle of albitite between locality 2 and 3 (and 4)

but contains abundant metallic hematite as well as a small vein of late potassic alteration (see photograph).

Sample Sites:	Sample Number	1:100 000 Map Sheet	Grid Reference
	86206091	MOUNT ANGELAY	628567

Access: Continue back to Eureka and take the road trending NNW towards Cloncurry. The granite is extremely variable and a few stops in it will show you this. The site I have selected is a small knob on the west side of the road, about 200m north of a creek crossing.

Geology: This is a pure white albitite with hematite. It is also enriched in Zr (886 ppm), and is one of the highest values in the batholith.

Comment: This albitite pipe shows how in some altered areas, the so called immobile elements are quite mobile: perhaps they may be used as indicators of fluid pathways and alteration.

Locality 4 — Early and late intrusive phases on the western edge of the Mount Angelay Granite

Introduction: This was a very well exposed section visible on the air photographs. It is actually a waterfall and makes a lovely lunch spot (provided that there isn't a dead cow in it as happened to us once). I was also attracted to this site as the granite is shown on the maps as intruding Soldiers Cap Group, but on the original on the air photograph overlays it is actually recorded as Corella calc-silicates.

Sample Sites:	Sample Number	1:100 000 Map Sheet	Grid Reference
	86206092	MOUNT ANGELAY	636805
	86206093	MOUNT ANGELAY	636805

Access: Continue following the road to Cloncurry. The site is to the east of the road, just after it turns to the northwest, but before it starts to descend. From memory, there is a little knobby hill and a small clearing on the south side of it. Walk though to the waterfall, although the sample sites were taken on the south side of the knob, buried in some bushes (environmental geology !!!)

Geology: This site exemplifies the complex relationships between the early and late phases. There is extensive veining of late aplitic-type veins into and earlier, coarser granite (see photograph). There is no Au in these samples. Both the coarse and the fine types are altered in K, and they contain 20 and 18 ppm U respectively. I interpret this part of the pluton to be late stage and fairly fractionated.

Comment: Because there is little mineralogical or chemical difference between the coarse and the

Albitite locality ③.

Early (coarse grained) and late (fine grained) intrusive phases at Locality 4

fine grained types there is little interaction between the two types — compare this with the Wimberu Granite. I interpret the Mount Angelay pluton to be one of the more fractionated plutons of the Williams Batholith from which there is obvious late stage veining, which disseminates out into the country rocks. It is a pity that they are dominated by calc-silicates, as the granite, apart from brecciating them, appears to be allergic to the calc-silicates. It is quite noticeable that most of the mineralisation in the vicinity of the Williams Batholith is hosted by iron-rich mafic volcanics, carbonaceous shales, magnetite bearing felsic volcanics, or massive ironstones - there is little if any in the Doherty/Corella calc-silicates.

Locality 5 — Saxby Granite

Introduction: This is just s brief stop at one of the plutons of the Saxby Granite. As you can see on the BMR radiometrics image some parts of the pluton are highly radioactive. In places there is net veining.

Sample sites:

Sample Number	1:100 000 Map Sheet	Grid Reference
84536104	MOUNT ANGELAY	637740

Access: Continue on road from last site. Locality is in a steep part of the road.

Geology: The Saxby Granite tends to be finer grained that the other Williams plutons. Near the dolerite marked on the map there are often good net-vein complexes developed.

Comment: The net veining here is common in other localities of the Williams Batholith and suggests that there was mafic intrusions synchronous with the granite emplacement.

Locality 6 — Type locality of the Gilded Rose Breccia

Introduction: I will say little about this locality as I cannot improve on the description of Rod Ryburn in the Cloncurry notes which I have provided you with. The type locality is at GR CLONCURRY 625025.

Access: Just follow the original Landsborough Highway from Cloncurry

Comment: Rod Ryburn established the stratigraphic name "Gilded Rose Breccia" for the breccias that were related to the intrusion of the Williams and Naraku Batholiths. From memory, most of the small circular pink areas shown on the Cloncurry Sheet area as either Naraku or Williams Batholiths are pure white albitites (if they are unweathered).

Traverse 4 — Tank Hole Bore — highly fractionated granite, plus additional alteration types.

Overview: The granite to the south of Tank Hole Bore (GR MOUNT ANGELAY 503615) shows up as a radiometric anomaly. In addition the other granite to the west of Glen Eva Homestead (GR MOUNT ANGELAY 489556)shows interesting alteration.

General Access: The track leaves the Selwyn Road at GR MALBON 416510. I don't remember anything difficult about it.

Locality 1 — Interesting hydrothermal alteration.

Introduction: This site contains some bizarre styles of alteration. I was attracted to this pluton because the breccias are actually in the clastic Staveley Formation.

Sample Sites:

Sample Number	1:100 000 Map Sheet	Grid Reference
88206003	MALBON	459581
88206004	MALBON	459581
88206005	MALBON	460582

Access: This site is right at the junction of the road to the two Bobs Copper Mine (22.4 tonnes Cu) and Tank Hole Bore with the road to Glen Eva Homestead.

Geology: There is a beaut sample site right at the intersection in which the granite contains a fair amount of sulphide. There is also abundant iron staining in the rock. Sample 88206005 came from about 100m to the northeast in some red-rock alteration. Unlike many other red-rock sites, which are dominated by potassic alteration, these are sodic and the rock sampled contains 7.08wt% Na_2O and 0.08 wt% K_2O.

Comment: I selected this site to show the variation in alteration. The moral of the story is take care when identifying the chemical composition of alteration types by the colour of the rocks. The red colour of the Na-rich altered granite may in fact be due to influence of the ancient weathering profile. As I have noted before, the white albite-rich rocks contain metallic hematite and further oxidation of these may impart the red colouring.

Locality 2 — Pluton south of Tank Hole Bore

Introduction: This is a highly uraniferous pluton and is highly fractionated

Sample Sites:

Sample Number	1:100 000 Map Sheet	Grid Reference
88206000	MOUNT ANGELAY	502546

Access: Follow the road north from the previous site. The sample contains 39 ppm U.

Geology: Plain old fractionated granite. Non of the three samples collected from this pluton any significant Cu or Au.

Comment: Although highly fractionated, non of the samples from this pluton have any significant metals present. The high U may be significant in that it may be responsible for later hydrothermal circulation due to radiogenic heat. The possible effects of later

hydrothermal circulation caused by this radiogenic heat decay has distinct metallogenic possibilities.

Traverse 5 — The Southwestern Plutons.

Overview: This is a trip to a few localities in the southern plutons. Most of the granites on the Selwyn Sheet are fairly innocuous — alteration is not as extensively developed and the plutons, with the exception of the Gin Creek Granite, are not as fractionated. I interpret these more southern plutons to be intruding at deeper crustal levels in the granite. Another difference is that calc-silicate rocks are not as abundant as in the north on the Mount Angelay Sheet area. Please remember that in this southern sheet area, the regolith profile is fairly thick and leaches out K_2O, Th, and U: it may lead to misleading interpretations of radiometrics.

General Access: Just follow the road to the Starra deposit.

Locality 1 — Gin Creek Granite tourmaline nodules, pegmatites.

Introduction: The Gin Creek Granite is one of the fractionated granites of the Williams Batholith. It also shows features of late stage hydrothermal magmatic activity which is not as common in other fractionated plutons. These include greisens, tourmaline nodules (see photographs), pegmatites, late stage aplites etc etc. Most of the pluton is affected by an ancient regolith which leaches out all of the K_2O, Th and U — in fact on some maps the granite was mapped as "sandstone". In some places, the tourmaline nodules actually persist in highly weathered material, confirming that it is not a sandstone !!! If you look at the Selwyn geological map, the main granite mass is actually two plutons separated by a road which runs west from Starra to Gin Creek Bore. Most of the southern pluton is high grade metamorphics, but within them there are greisen and aplite veins which belong to the Williams Suite. The northern pluton is mostly Williams suite type and some sample have up to 13 ppm U.

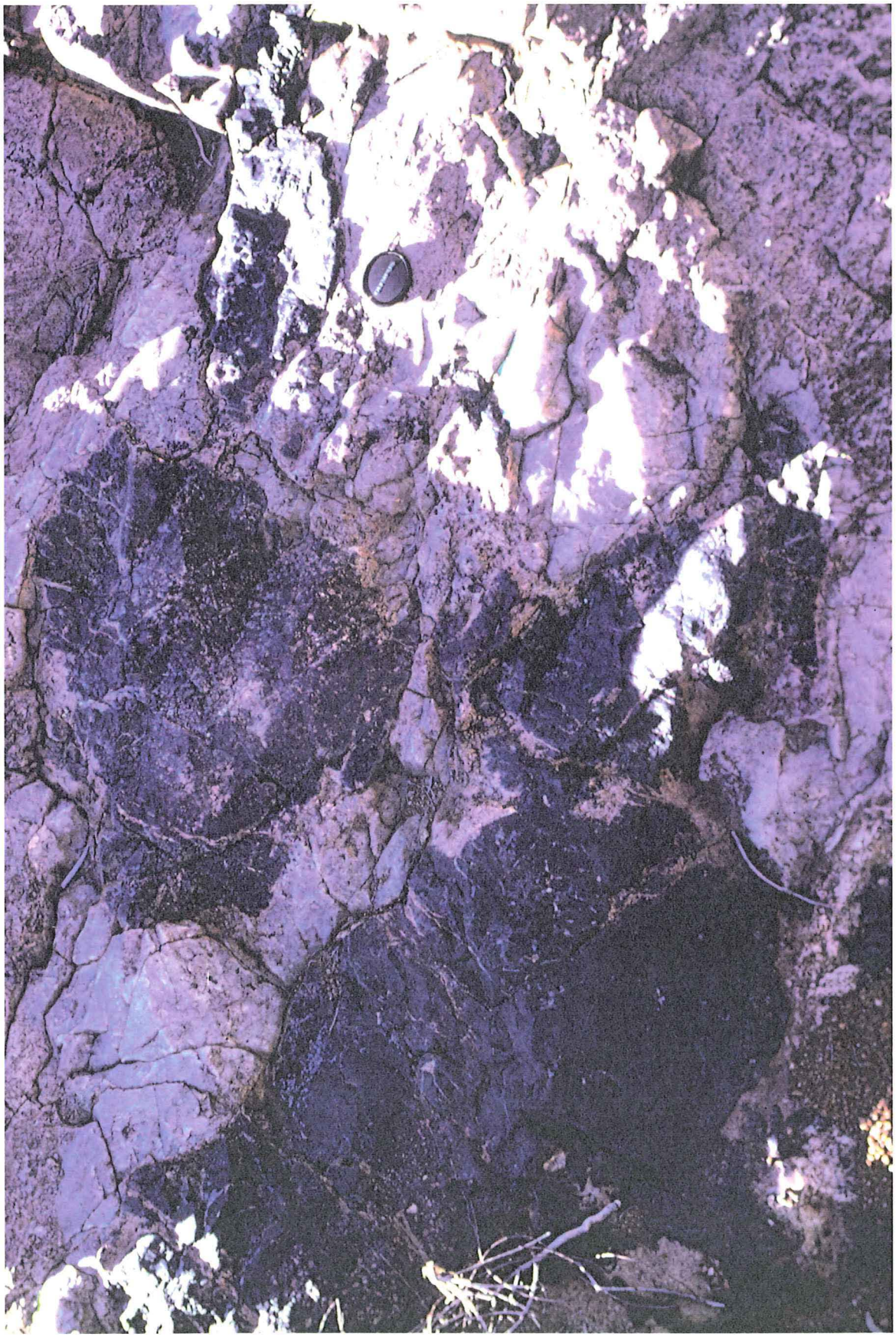
Sample Sites:

Sample Number	1:100 000 Map Sheet	Grid Reference
86206134	MOUNT MERLIN	427045
86206133	MOUNT MERLIN	431044
88206012	MOUNT MERLIN	443044
88206013	MOUNT MERLIN	443044

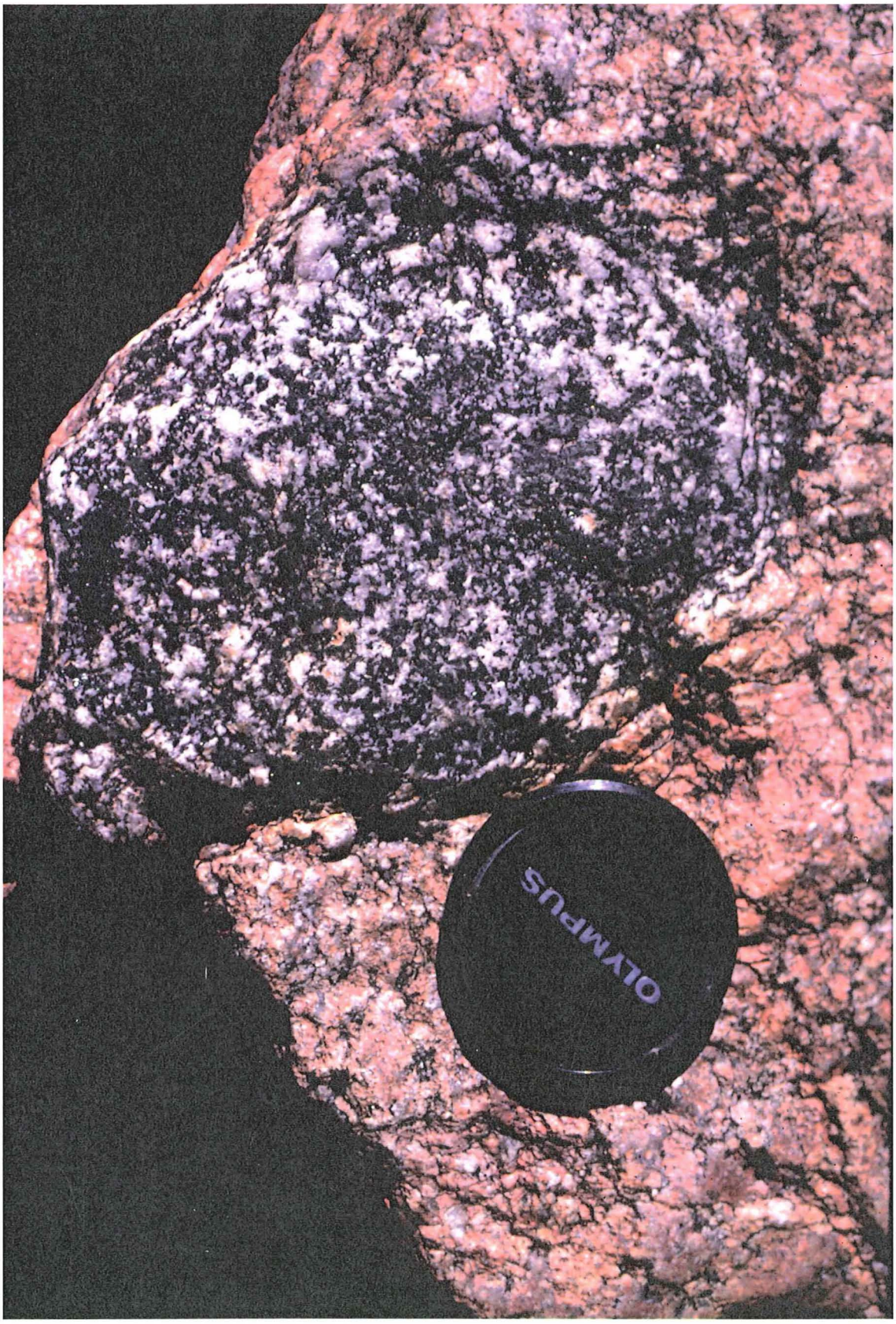
Access: Help. My memory is failing. If you have recent (post 1986) photographs this traverse should be no problem as there is a major fence line along which these samples were collected. I seem to remember that we left the main road at GR MOUNT MERLIN 454090 and traveled west to pick up the fence line and then followed it to the localities. The fence line runs up the creek (??) or at least a track does. The best locality is GR MOUNT MERLIN 443044 (Samples 88206012 and 88206013) as it contains nice tourmaline nodules and some pegmatites (see photographs). The are exposed in a small waterfall in the creek to the north of the track. From this locality you can keep going, and I think that we let the fence down, traveled cross country and ended up at the Starra explosives store. We were not welcome, so I would not advise this exit route.

Geology: The granite here is fairly felsic and fractionated. There are large tourmaline nodules in the outcrop.

Comment: From this locality you can hear the operations at Starra. As you can see, this is a very juiced up granite. I have no doubt that it is associated with Starra.



Tourmaline nodules —
Gin Creek Granite



Tourmaline quartz nodules
locality 1 - Gin Creek Granite

Mica pegmatite dykes
Gin-Creek granite

Locality 2 — Mount Cobalt Granite

Introduction: This is a very cute little granite pod. I hope you can find my localities.

Sample Sites:

Sample Number	1:100 000 Map Sheet	Grid Reference
85206008	SELWYN	512006
85206009	SELWYN	512007

Access: Follow the main road south past Starra. You can do a trip through the Mount Dore Granite, but it is a pretty boring, homogeneous felsic granite. The Mount Cobalt localities are on the northside of the pluton. We went cross country from the road, before it crosses the Mort River.

Geology: This pluton has interacted with the Kuridala Formation at the margin. Some marginal phases are green and contain pyrite, whilst the rest of the pluton is a red homogeneous magnetite bearing granite.

Comment: This site also shows that carbonaceous sediment interact and influence the granite mineralogy and composition.

Locality 3 — Yellow Waterhole Granite

Introduction: This is a complex granite which I believe is made up of a series of many small intrusions, some of which are highly fractionated. From the map you can pick where the fractionated phases are — they are the areas of dense jointing. They also correspond to total count highs on the BMR regional radiometrics.

Sample Sites:

Sample Number	1:100 000 Map Sheet	Grid Reference
84536114	SELWYN	532910
84536115	SELWYN	532904
84536116	SELWYN	609911
84536117	SELWYN	614907

Access: Just keep following the main road.

Geology: **Site 1**: is around GR SELWYN 532910. It consists of the coarse grained Yellow Waterhole Granite. Sample 84536115 (GR SELWYN 532904), although red in colour, has sodic alteration with 5.37 wt% Na_2o and 0.84 wt% K_2O: it also has high Cu (67 ppm) but no Au. This sample is close to the geochronology site and that sample is as altered, if not more altered than this.

Site 2: is around the eastern side of the Yellow Waterhole Granite and was collected

to look at the radiometric anomaly and also the area of high jointing. This area tends to be much finer grained, higher in Rb and more fractionated.

Comment: This granite is much more diverse than previously realised. It also has highish U (up to 16 ppm) and ample evidence of hydrothermal alteration. Again, an area of high jointing as shown on the geological map corresponds to an area of fractionated granite, and perhaps if that is what is required, it may be a quick way of targeting areas of fractionated granite.