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Mineralogy and Petrology of Uranium Occurrences in the Thekulthili Lake Area, Northwest Territories, Canada

— The 1983 Report —

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Mineralogy and Petrology of Uranium Occurrences in the Thekulthili Lake Area, Northwest Territories, Canada -- The 1983 Report --

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要　旨

1983年度に行なった鉱物試験の結果，テクルシリレイク地域におけるウラン鉱化作用には次のような特徴が認められる。

(1) Kult 51および82鉱区におけるウラン鉱化作用はマイロナイト化作用に伴う葉状構造に規制されている。

(2) 両地域のウラン鉱化作用はやや弱くマイロナイト化された個所に集中する傾向がある。より強く変形されマイロナイトそのものになった部分や，逆に弱い変形だけのカタクレーサイトの部分には，ウラン鉱化作用は弱くなるようである。これら(1)(2)の事実は効果的な鉱区設定や探鉱活動を可能にする。

(3) ウラン鉱徴地を中心とする変質ハローが両地域で認められた。この変質ハローは主として緑泥石の組成変化（鉱化帯に近づくにつれMgに富む傾向）により特徴づけられる。その分布は岩石構造に規制され，鉱化帯の下盤側，上盤側，走向方向の順に広くなっている。今後，変質ハローの中心を求める事により地下鉱体の位置をさぐる事ができる。

(4) Kult 59におけるピッチブレンド脈はNE系断層周辺に集中する2次小断層系であると考えられる。

(5) 角閃石と黒雲母の，K−Ar年代とArの閉止温度からKult 59における温度一時間曲線が描かれた。この関係とピッチブレンドのPb−Pb年代からその生成温度は480～500℃とと推定された。これらの考察から，当地域の初生ウラン鉱化作用はハドソニアン造山運動に属する変成作用の後退期における熱水作用によるとみなされる。

（なお本報告書の邦文は「昭和58年度カナダ北西準州テクルシリレイク地区調査報告書」に添付されているので必要に応じて参照されたい。）

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Mineralogy and Petrology of Uranium Occurrences in the Thekulthili Lake Area, Northwest Territories, Canada
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Abstract

Descriptions are given of some uranium occurrences in the Thekulthili Lake Area, Northwest Territories, Canada, and the following conclusions are obtained:

(1) Uranium mineralizations found in Kult 51 and 82 claims are governed by the foliation associated with mylonitization. Pitchblende veins in Kult 59 claim appear to be the secondary fault system subordinated to the major fault system.

(2) Significance of mylonitization to the uranium mineralization is noteworthy; pitchblende deposition is probably restricted to the area where rocks of weakly or moderately mylonitized nature are distributed.

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(3) Alteration halo is recognized around uranium occurrences in Kult 82. Most prominent and diagnostic phenomenon of the halo is that the Mg content in chlorite tends to increase from the unmineralized zone to the mineralized zone. The halo becomes wider in an asending order: footwall, hanging wall and strike, extending more than 200 m. The alteration halo can be the factor leading to discovery of blind deposits.

(4) Combination of K-Ar dates and closure temperature of Ar in hornblende and biotite, together with Pb-Pb dates of pitchblende, leads to a hypothetical temperature-time relationship in Kult 59, and the temperature, 480-500°C, of pitchblende deposition is obtained. Thus the initial uranium mineralization in the area must be due to hydrothermal process in the stage of retrogressive metamorphism of the Hudsonian Orogeny.

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I. INTRODUCTION

The Thekulthili Lake area is located approximately 160 km NE of Fort Smith, N.W.T. at approximately 61°N latitude and 110°S longitude as shown in Figure 1.

Mineralogical and petrological studies* of 1982 field season on the Thekulthili Lake area have revealed that (1) many uranium occurrences in the area can be classified into 9 groups from the following viewpoints; a) presence or absence of pitchblende veins, b) continuity of the mineralized zone, c) degree of alteration and d) structural control, and that (2) most favorable are those found in slightly mylonitized rocks of either oligomictic conglomerate or the basement rocks.

The objectives of the present work are (1) to reveal genetic relationship between uranium mineralization and mylonization, (2) to explain relation between uranium mineralized veins and rock fabrics**, and (3) to interpret nature and scale of the alteration halo and (4) to determine the age of the mineralization.

The results are described below in short.

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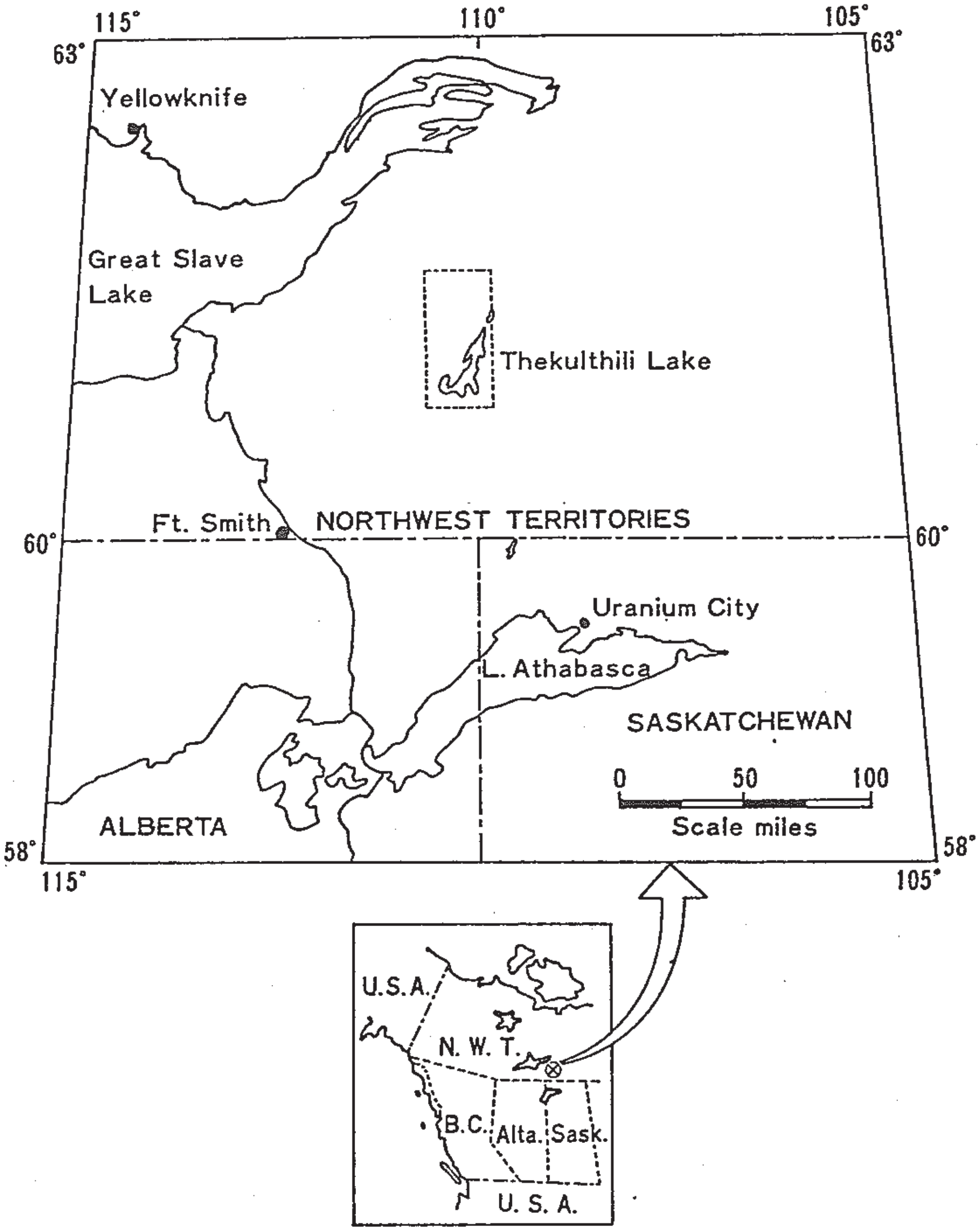
* Mineralogical and petrological studies of 1982 field season on the Thekulthili Lake project is presented in the appendix.

** The determination of the structurally favorable loci for localization of uranium deposits is of fundamental significance for uranium exploration. Morton et al. (1972) investigated Fay Mine Deposits, Beaverlodge area, and found that the foliation of the Hudsonian Orogeny controlled the pitchblende deposition.



FUGURE 1. LOCATION OF THEKULTHILI LAKE AREA

II. PETROFABRIC STUDIES

Structural features recognized in Kult 51, 82 and 59 include foliations, microfolds, minor faults, striations, pitchblende veins and veins of alteration minerals. Figures 1 ∿ 3 show the stereographic projections of the structural data and the characteristics are summarized below.

1. Kult 51

(1) The foliation in the mylonitized oligomictic conglomerate is fairly accord with the trend (NNE) of the major fault. This together with the fact that mylonitization is restricted in the vicinity of the major fault, shows that the mylonitization is closely related to the major faulting.

(2) Many minor faults found in Tr. A, B, and D have a NNE direction and many of the striations on the fault planes show NE ∿ S direction. These minor faults can be explained to be accompanied by the major faulting.

(3) Axial planes of microfolds trend ENE and dip S and the axes are also plunging S. Field observations show that the microfolds are a sort of flow folding, related to the mylonitization.

(4) Calcite veins and some of the joints are perpendicular to the foliation, and may be tension crack.

(5) Uranium mineralized veinlets are in the same trend with the foliation.

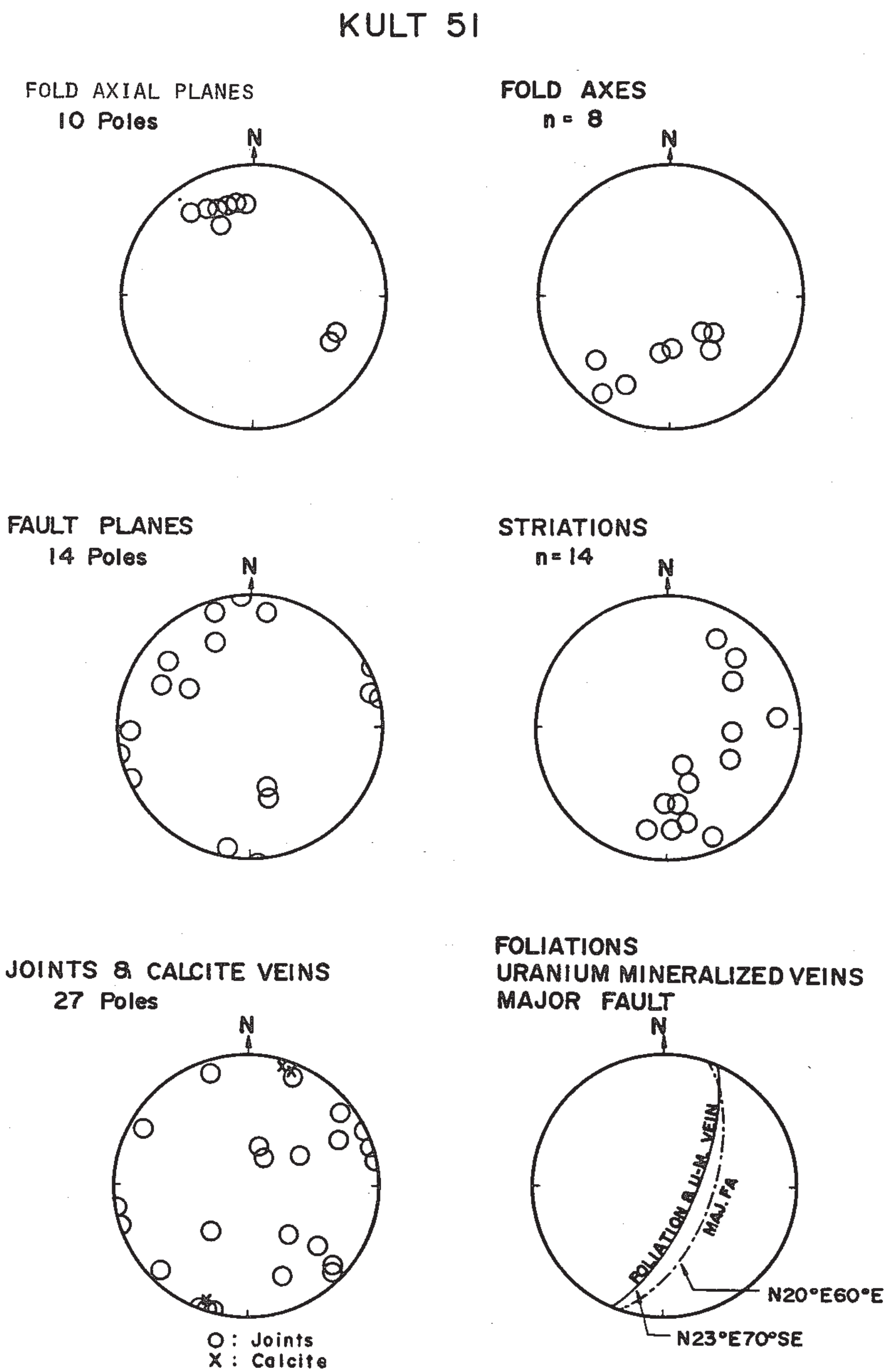


FIGURE 2. LOWER HEMISPHERE EQUAL-AREA PROJECTION OF STRUCTURAL DATA FROM KULT 51 AREA

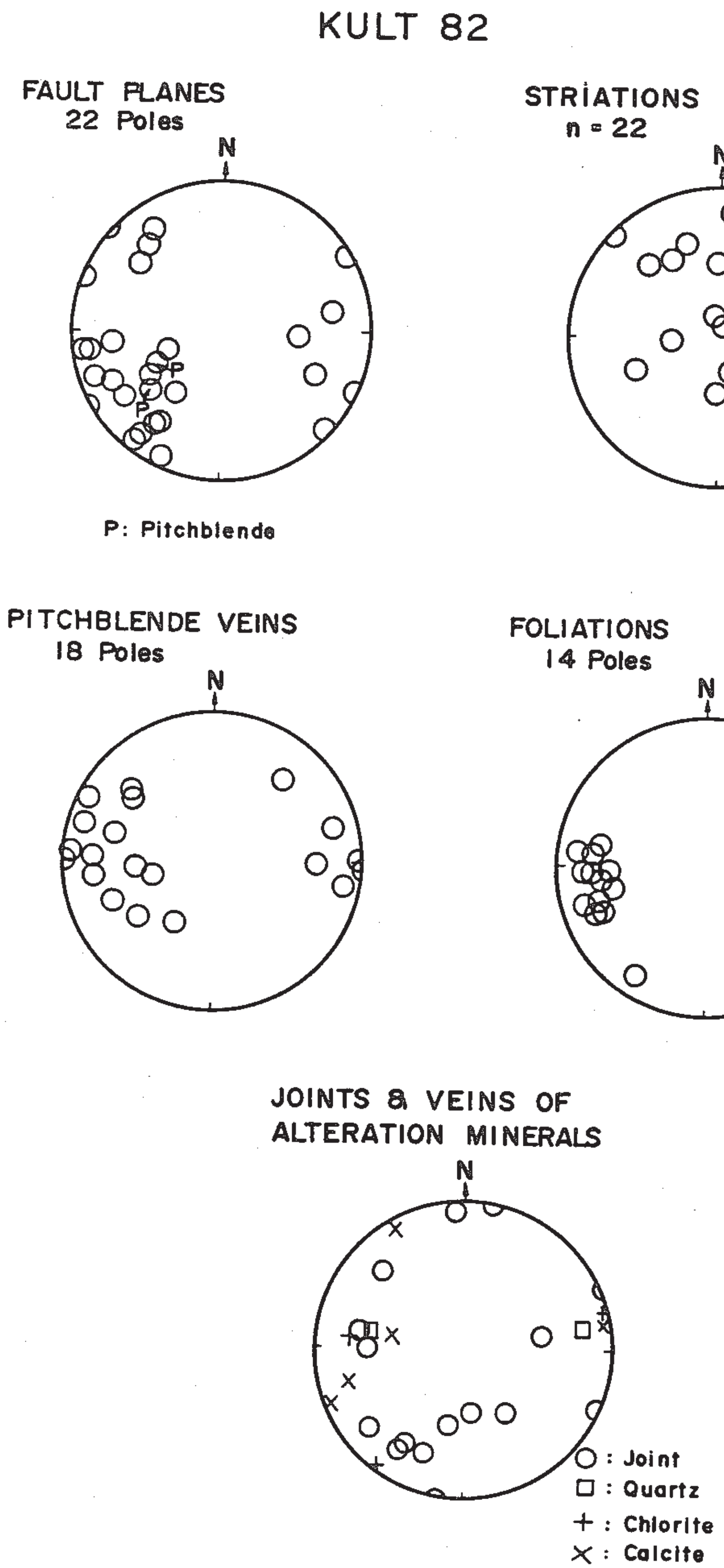


FIGURE 3. LOWER HEMISPHERE EQUAL-AREA PROJECTION OF STRUCTURAL DATA FROM KULT 82 AREA

(6) The uranium mineralization is found associated with chlorite veinlets and is concentrated on the slightly mylonitized oligomictic conglomerate. Drilling results have confirmed that more strongly mylonitized parts have less uranium mineralization.

The available data of the petrofabric study on Kult 51 area support the conclusion that structural factors found in Kult 51 area are related to the major faulting and mylonitization. The uranium mineralization is governed by such a structural control as mentioned in (5).

2. Kult 82

(1) Pitchblende veins occur in an almost similar fashion as minor fault does. The presence of striations in some pitchblende veins and their modes of occurrence suggest that some, probably many, of the pitchblende veins are a variety of "Fault Vein".

(2) Some minor faults and pitchblende veins are bowed the directions within the range of ±20°, perhaps due to local plastic deformation in the dynamically heterogeneous rock. The range of deviation permits the view that minor faults and pitchblende veins are well arranged around the foliation.

(3) Trends of veins of alteration minerals fall within the range of those of minor faults. The veins are some of minor faults, and presumably of joints, impregnated with the alteration mineral.

In conclusion, general feature of structural data in Kult 82 is that foliations, pitchblende veins, minor faults, joints, and veins of alteration minerals tend to strike N and dip E, and in the order mentioned, degree of concentration becomes lower. (Such a tendency is also the case with Kult 51.) Trends of pitchblende veins are found to be mostly within ±20° of that of foliation.

3. Kult 59

(1) The foliations found in this claim are trending EW and dipping S, whereas scattered distribution of joints is noticed, although some are concentrated to the same direction of the foliation.

(2) Pattern of trend of uranium mineralized veins* is very similar to that of joints. Veins of secondary uranium minerals are probably a variety of joints impregnated with such minerals.

(3) Similar patterns are recognized between trends of joints and those of veins of alteration minerals, suggesting that the latter is a sort of joints where alteration minerals are precipitated.

(4) Minor faults can be classified into three: those with NW∿WNW strike and N dip, those with NE strike and S dip, and those with almost horizontal trend. The former two correspond to the NW trending fault system and the

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* Veins in which secondary uranium minerals such as uranophane are found, those where only radioactive anomaly is recognized, etc. Pitchblende veins are not included.

KULT 59

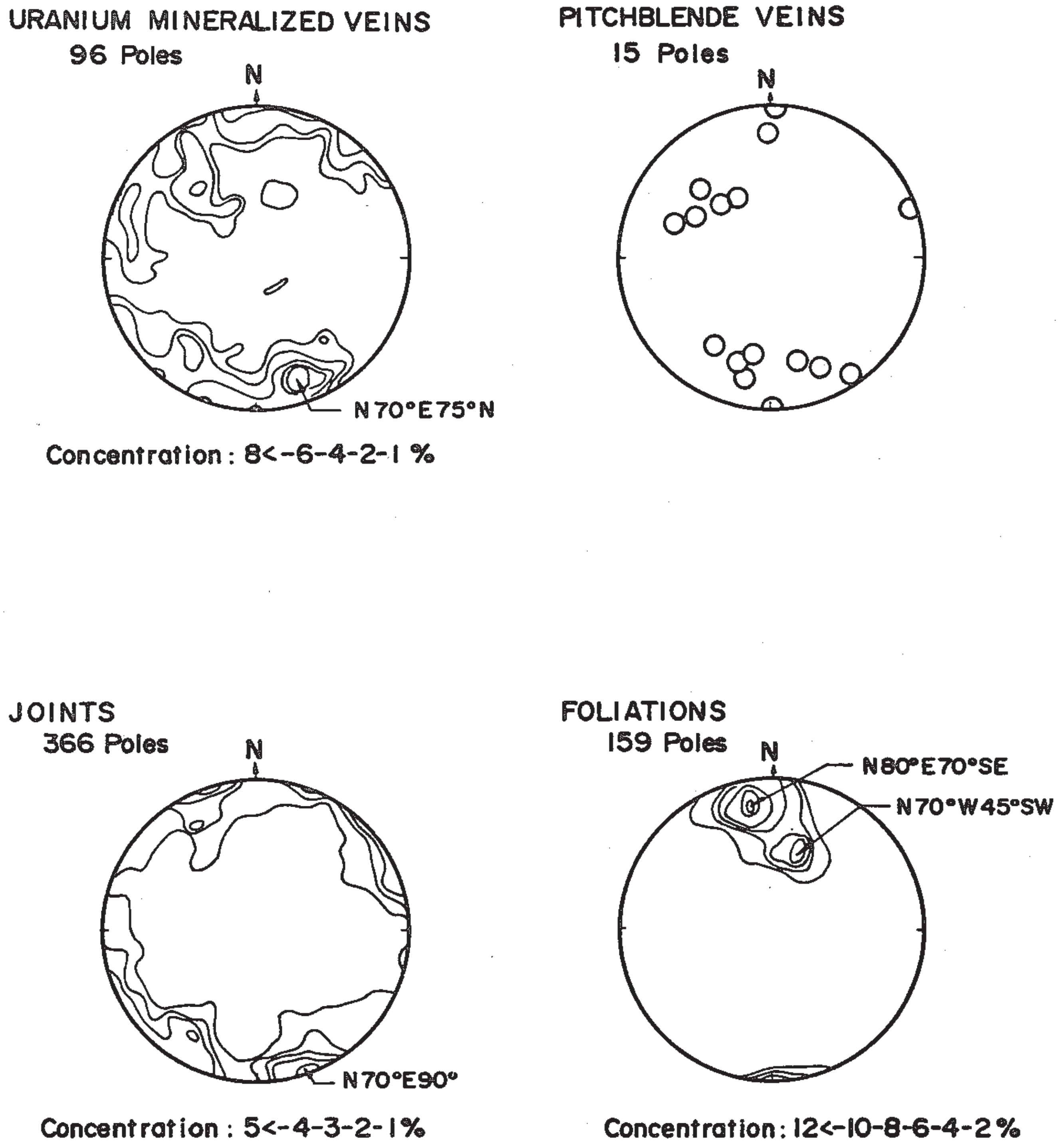
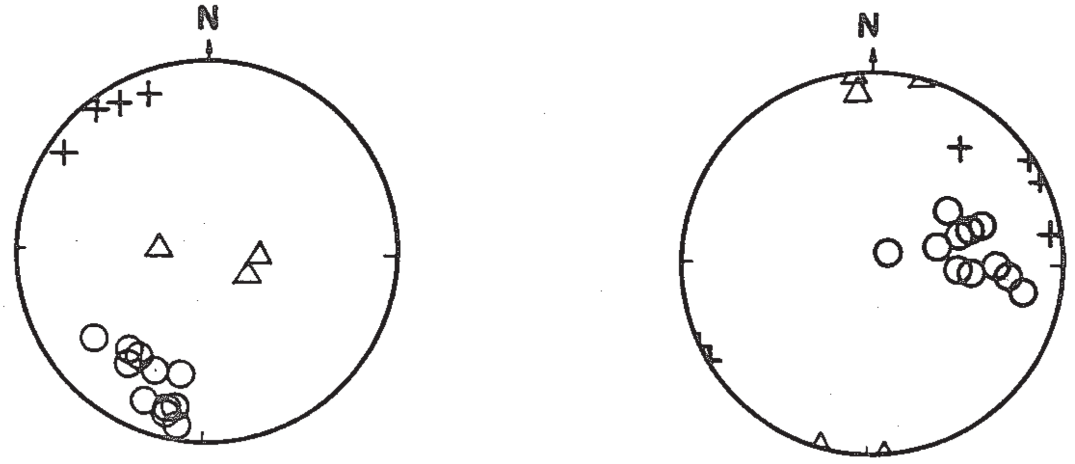


FIGURE 4. LOWER HEMISPHERE EQUAL-AREA PROJECTION OF STRUCTURAL DATA FROM KULT 59 AREA

KULT 59

FAULT PLANES
18 Poles

STRIATIONS
n = 18



Concentrations	Fault Planes (mean)	Striations (mean)
○ 11/18	N63° W62°NE	82°∠45°
+ 4/18	N52° E78°SE	55°∠20°
△ 3/18	N33° E 8° NW	20°∠ 6°

CONJUGATE FAULTS

VEINS OF ALTERATION MINERALS
20 Poles

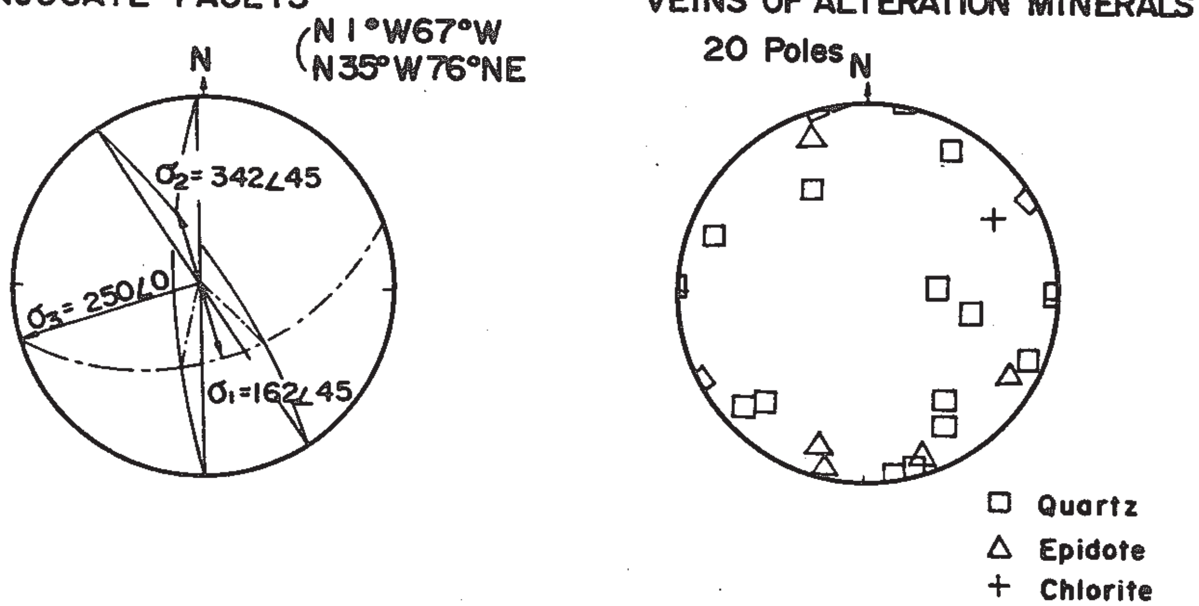


FIGURE 4. LOWER HEMISPHERE EQUAL-AREA PROJECTION OF STRUCTURAL DATA FROM KULT 59 AREA CONT'D

NE trending system respectively, both of which are shown in the geologic map of Kult 59.

(5) A set of conjugate minor faults is found in the area. The determination of the stress field suggests that this faulting is neither contemporaneous with the formation of foliation nor with the minor faulting.

(6) The NW ∿ W ∿ ENE trend and NE trend of pitchblende veins corresponds to the NE ∿ W and the NE trends of the minor faults respectively.

In short, field studies in Kult 59 area lead to the following conclusions: (a) Uranium mineralization tends to concentrate in the vicinity of the NE fault system, (b) The pitchblende vein has two directions, one is parallel, and the other oblique to the fault system, and (c) the vein system might be the secondary fault system subordinate to the major fault system.

III. SIGNIFICANCE OF MYLONITIZATION TO URANIUM MINERALIZATION

For a quantitative expression of dynamic deformation of crystalline rocks in the Tazin Group, Eldorado Fay Mine, Krupicka and Sassano (1972) used the following four scales: degree 1 (strain rocks), degree 2 (cataclastic rocks), degree 3 (mylonitic rocks), and degree 4 (ultramylonitic rocks). The Fay Mine Complex where the most intense uranium mineralization is recognized, is referred to as a transition from deg. 2 of mylonitization to deg. 3, and pitchblende is formed at the close of the main deformation sequence and frequently replaces pyrite associated with chlorite veinlets.

Such quantitative scale can be adopted to Kult 51 and 82 area. In the former area, eastward unmineralized part is deg. 1 ∿ 2; (narrow) mineralized part (Tr. A, B and D), deg. 2 ∿ 3*; and westward un- or weak mineralized part (mylonite), literally deg. 3.

Also microscopic observation on all the samples from Kult 82 area (Table 2) prove that the zone of deg. 2 ∿ 3 is fairly wide, probably more than 200 m.

Thus the uranium mineralization both in Beaverlodge and in Thekulthili Lake area must be confined to the area where rocks of weakly or moderately mylonitized nature (deg. 2 ∿ 3) are present.

Kult 82 is more promising than Kult 51, judging from the degree of mylonitization.

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* This may be explained as follows; Permeation of mineralizing solution must be governed by the degree of fracturing and porosity. As mylonitization become more intense, fracturing also becomes more abundant, which leads to a maximum "Fracture Porosity" (Drummond, 1964) in the middle (deg. 2 ∿ 3) of mylonitization. Furthermore as deformation is promoted, mineral grains then become very fine-grained aggregates and decrease of "Fracture Porosity" may result in decrease of permeation of the solution.

TABLE 1. LIST OF PEAKS USED FOR "PEAK MODE ANALYSES*"

Mineral	2θ (Cukα)
Quartz	26.7°
Microcline	27.5°
Plagioclase	27.8° + 28.0°
Chlorite	6.2° + 12.4° + 18.6°
Mica	8.7° + 17.5°
Calcite	29.4°
Hematite	33.2°
Magnetite	35.4°

* "Peak Mode" means relative amounts of the constituent minerals estimated from peak intensities of X-ray diffraction.
The results of "Peak Mode Analyses" are used only for mutual comparison.

TABLE 2. RESULTS OF MINERALOGICAL STUDIES ON SELECTED SAMPLES FROM KULT 82

Sample No.	Location	Rock Name	Radioactivity* (cps)	U (ppm)	Fe^{+3}/Fe^{+2} (rock)	Fe ore**	Chl Comp	Mica Comp	Peak Mode Analyses (%)*** Q	Mr	Pl	Ch	Mi	Ca	He	Ma
(Line A-A')																
1311	0+10N 1+00E	01.congl.	105 (80)	0.1	0.6	He	2.44	0.22	46	13	20	4	10	6	1	0
1312	0+30N 0+50E	"	110 (75)	0.0	1.3	He	2.62	0.25	34	14	22	9	16	4	1	0
1313	0+30N 0+25E	"	120 (110)	0.2	0.6	He	2.30	0.23	32	9	28	16	13	2	1	0
1314	0+30N 0+00	"	n.d.	0.5	0.5	He	2.17	0.23	28	12	28	13	12	7	0	0
1315	0+25N 0+15W (South Wall of Tr.6)	"	"	3.2	1.0	He	2.64	0.22	30	12	30	14	12	1	0	0
1316	0+30N 0+25W	"	"	0.2	0.6	He	2.76	0.22	36	13	18	16	14	3	0	0
1317	0+30N 0+50W	"	120 (11)	1.9	0.4	He,(Ma?)	2.63	0.18	32	8	20	21	15	3	0	0
1318	0+30N 0+75W	"	n.d.	0.0	0.7	He	2.50	0.21	27	8	36	15	10	4	1	0
1323	Tr.1	"	"	7.0	1.7	He	2.37	0.17	16	0	48	18	12	3	2	0
1319	Tr.3	"	"	0.36%	4.4	n.d.	2.43	n.d.	52	7	11	7	23	0	0	0
1320	1.3m west from Tr.3	"	"	2.6	1.5	He	2.48	0.22	35	11	20	10	18	4	1	0
1501	0+30N 1+00W	"	250?(250?)	1.0	1.2	He	2.45	0.24	34	11	27	14	13	1	1	0
1502	0+30N 1+25W	"	120 (n.d.)	5.6	1.3	Ma,He	2.58	0.20	42	11	23	8	13	4	0	0
1503	0+30N 1+50W	Mylonite	80 (70)	0.9	1.1	He	2.58	0.18	24	2	45	14	13	2	1	0
1504	0+30N 2+00W	01.congl.	90 (70)	0.1	1.8	Ma,He	3.23	0.16	35	5	27	17	7	9	0	0

TABLE 2. CONT'D (LINE B-B')

Sample No.	Location	Rock Name	Radioactivity* (cps)	U (ppm)	Fe^{+3}/Fe^{+2} (rock)	Fe ore**	Chl Comp	Mica Comp	Peak Mode Analyses (%)*** Q	Mr	Pl	Ch	Mi	Ca	He	Ma
(line B-B')																
1301	6+00S 0+90E	Ol.congl.	100 (80)	0.2	2.8	He	2.82	0.20	37	1	32	6	20	3	0	0
1302	5+85S 0+50E	"	110 (80)	1.5	0.8	He	2.25	0.24	26	13	35	13	9	4	0	0
1303	5+85S BL00	"	110 (80)	2.3	1.2	He	2.48	0.21	32	6	32	11	11	6	1	0
1304	5+85S 0+25W	"	100 (80)	1.7	1.4	He	2.41	0.23	46	3	19	8	19	4	1	0
1305	5+85S 0+50W	Mylonite	105 (90)	3.2	1.0	He	2.44	0.20	15	0	17	21	26	20	0	0
1306	5+85S 0+75W	"	100 (n.d.)	1.6	0.4	Ma,He	n.f.	0.19	4	0	0	0	57	39	0	0
1508	Tr.A(mineralized part)	"	>15000(n.d.)	70	0.9	Ma,He	3.46	0.18	2	8	60	14	17	0	0	0
1506	" (10cm from 1508)	"	n.d.	50	0.3	(He?)	2.92	0.15	6	0	15	52	24	2	1	0
1507	" (1cm from 1508)	"	n.d.	8.9	0.3	(He?)	n.d.	n.d.	14	1	2	55	17	10	1	0
1307	5+85S 1+00W	"	120 (n.d.)	0.2	1.9	He	2.29	0.24	27	2	53	4	10	2	1	0
1308	5+85S 1+25W	"	90 (85)	0.5	0.4	He	2.75	0.21	34	8	32	14	10	2	0	0
1309	5+85S 1+50W	"	85 (85)	0.2	0.5	Ma,(He?)	2.83	0.17	30	0	44	12	8	6	0	0
1310	5+85S 2+00W	"	70 (65)	0.6	1.9	Ma,(He?)	3.39	0.19	16	2	40	31	8	2	0	0

TABLE 2. CONT'D (LINE C-C')

Sample No.	Location	Rock Name	Radioactivity* (cps)	U (ppm)	Fe^{+3}/Fe^{+2} (rock)	Fe ore**	Chl Comp	Mica Comp	Peak Mode Analyses (%)*** Q	Mr	Pl	Ch	Mi	Ca	He	Ma
(line C-C')																
1508	same as mentioned above															
1506	same as mentioned above															
1507	same as mentioned above															
1511	Tr.C	Mylonite	n.d.	5.0	0.3	n.f.	2.60	0.21	22	21	19	36	1	0	1	0
1512	6+35S 0+95W (1m south from 1512)	"	>15000(n.d.)	3.3	0.8	He	2.91	0.19	18	6	32	28	14	3	0	0
1513	7+75S 1+75W	"	13000(n.d.)	40	1.1	He	2.65	0.18	13	4	40	22	13	7	0	0
1602	7+60S 1+75W	"	4000(70)	13.2	0.7	He	n.d.	n.d.	1	0	45	37	5	11	2	0
1603	7+50S 1+80W	"	1200(70)	200	2.4	He	2.57	0.17	1	11	38	28	13	6	2	0
1601	8+50S 1+50W	"	90(70)	0.5	1.3	Ma,He	3.12	0.20	38	9	21	12	15	4	0	0

* Radioactivity is measured in situ with spectrometer, SPP-2. Figures in parentheses are those of background intensities.

** Fe ore is identified by X-ray diffractometer after magnetic separation.

*** Relative amounts of the constituent minerals estimated from peak intensities of X-ray diffraction.

Chl Comp: A stractural formula of Fe-Mg chlorite is $(Mg,Al)_{6-y}Fe_y(Si,Al)_4O_{10}(OH)_8$, and the value of Y is given as indicating chlorite composition.

Mica Comp: The value is the ratio of 002/001 of X-ray diffraction intensities. The high value indicates high Al content in mica, for instance the range of 0∿0.15 indicates biotite, 0.15∿0.30 biotite + muscovite, 0.30∿0.40 phengite, >0.4 muscovite.

Q : Quartz, Mr: Microcline, Pl: Plagioclase, Ch: Chlorite, Mi: Mica, Ca: Calcite,
He: Hematite, Ma: Magnetite, n.f.: not found.

IV. STUDY OF ALTERATION HALO

In order to define the nature and distribution of alteration halo associated with the uranium mineralization in Kult 82 area, systematic sampling was carried out along (1) line A - A' traversing Tr. 1 and 3 of "Cole Prospect", (2) line B - B' traversing Tr. A, and (3) line C - C' running along trend of uranium mineralized zone and strike of host rocks.

Executed are both field and microscopic observations, "Peak Mode Analysis*", identification of iron ore minerals**, and determination of Fe^{+3}/Fe^{+2} ratio of rock***. Composition and crystallinity of chlorite and mica, as well as amount ratio of chlorite/mica were also determined using X-ray diffractometer. The results are summarized in Table 2 and Figures 4 ∿ 5, and outlined below.

1. (PRESENCE OF ALTERATION HALO) Mg content in chlorite tends to increase from the unmineralized zone to the mineralized

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* Modal analyses of the constituent minerals are carried out in the style of percentages of each integrated intensity of main X-ray peak (Table 1).

** A small amount of pyrite grains are often recognized in many outcrops, although pyrite is not identified in all the samples, and their sulphur contents are all below 0.01 %.

*** Determination of sulphur, ferrous and ferric contents are done by Exploration Technology Development Section, Chubu Exploration Office.

zone. This fact invokes the presence of alteration halo around uranium mineralized part in Kult 82 area.

2. (NATURE OF ALTERATION HALO) The halo involves not only (a) the variation of chlorite composition but also (b) change of magnetite zone to hematite zone, (c) variation of mica composition, (d) increase of chlorite quantity and (e) decrease of quartz quantity, although the latter two are obscure in the unmineralized zone.

   Variation of crystallinity of chlorite and mica, and chlorite/mica amount ratio are recognized on the samples from the line traversing Tr. B, Kult 51 area (see Appendix FIGURE 2 & TABLE 2). Similar trends, however, are not found in Kult 82 area.

   Most prominent and diagnostic phenomenon is the compositional variation of chlorite, with which pitchblende is ubiquitously associated.

3. (SCALE OF ALTERATION HALO) Chlorite composition still varies even at the outermost part. This implys the halo probably extends beyond the traverse line.

4. (RELATIONSHIP BETWEEN ALTERATION HALO AND PETROFABRICS) Figure 6 shows the relationship between the compositional variation of chlorite and the distance from the center of the mineralized zone. The gradient of the compositional variation of chlorite tends to be steep in an ascending

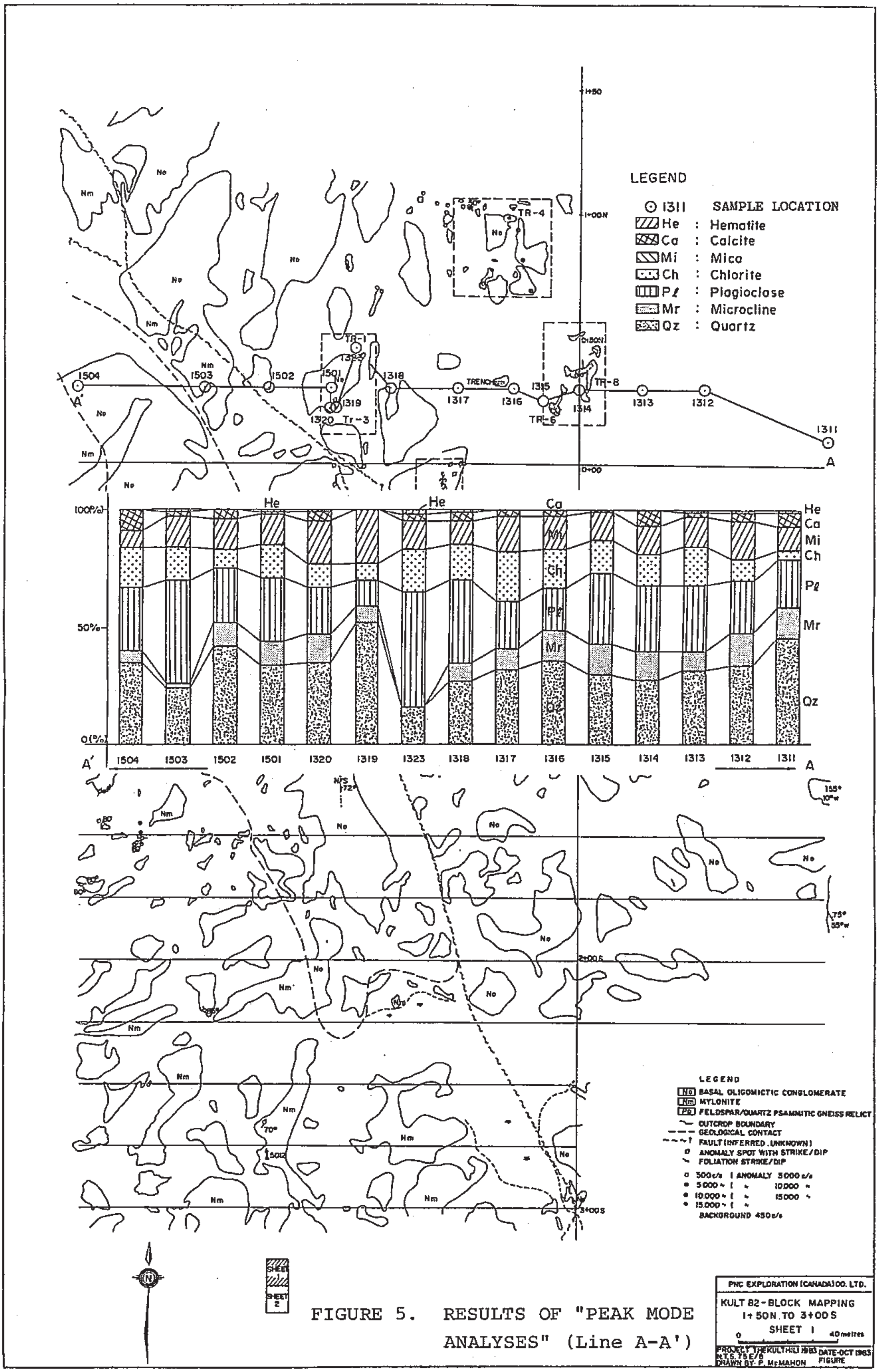


FIGURE 5. RESULTS OF "PEAK MODE ANALYSES" (Line A-A')

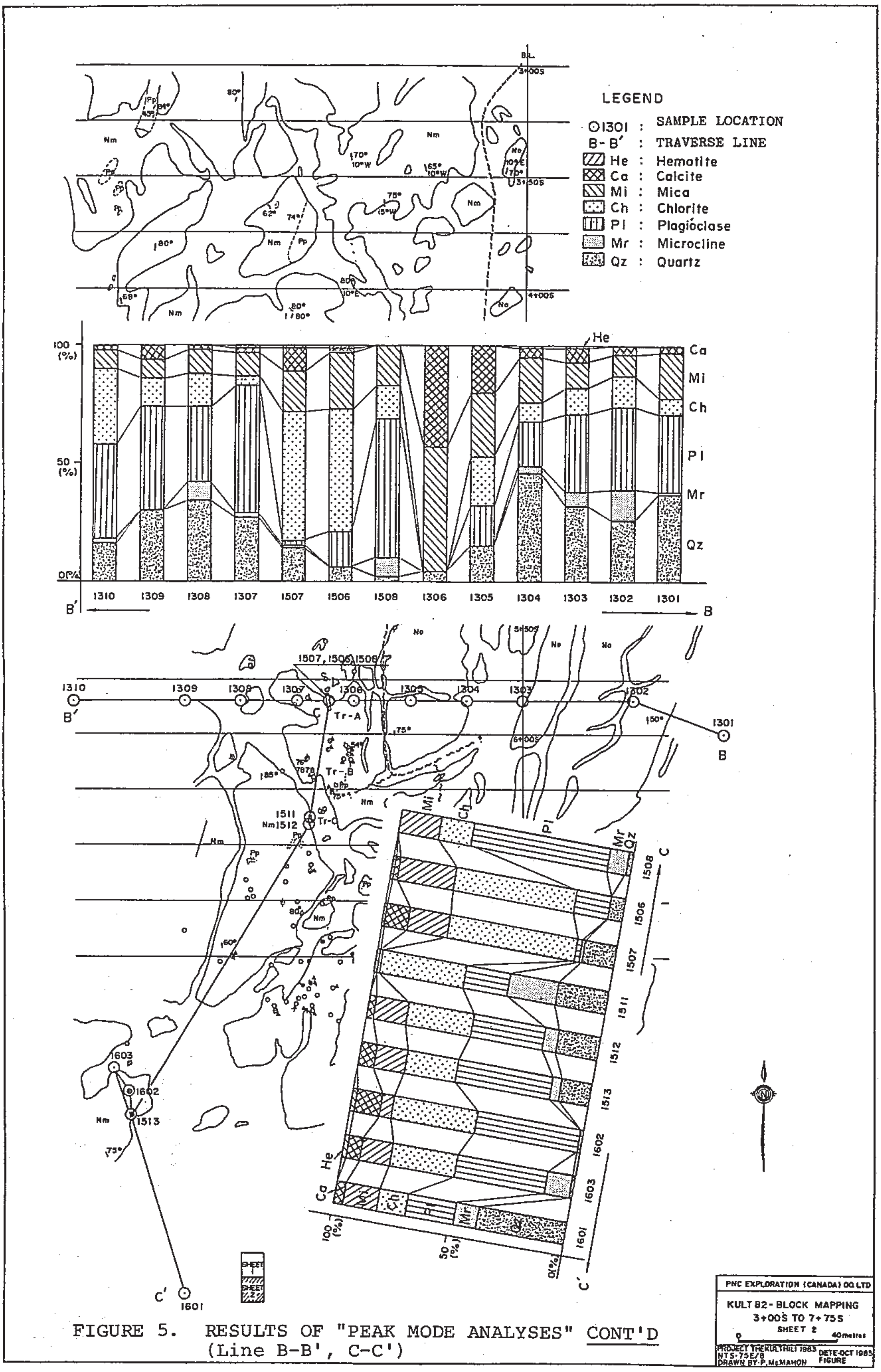


FIGURE 5. RESULTS OF "PEAK MODE ANALYSES" CONT'D
(Line B-B', C-C')

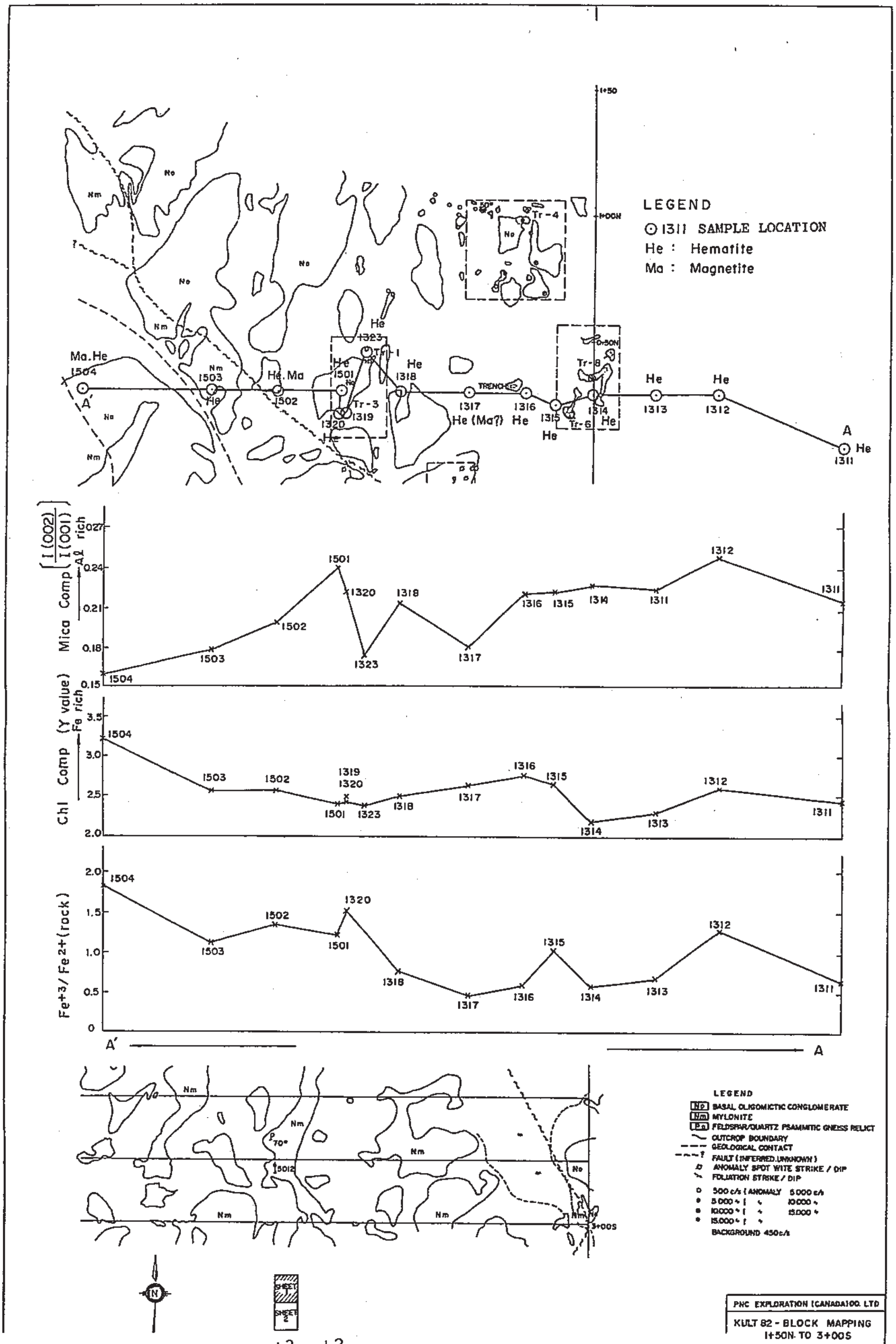


FIGURE 6. THE RATIO OF Fe^{+3}/Fe^{+2}, CHLORITE COMPOSITION AND MICA COMPOSITION OF SELECTED SAMPLES FROM KULT 82 AREA (Line A-A')

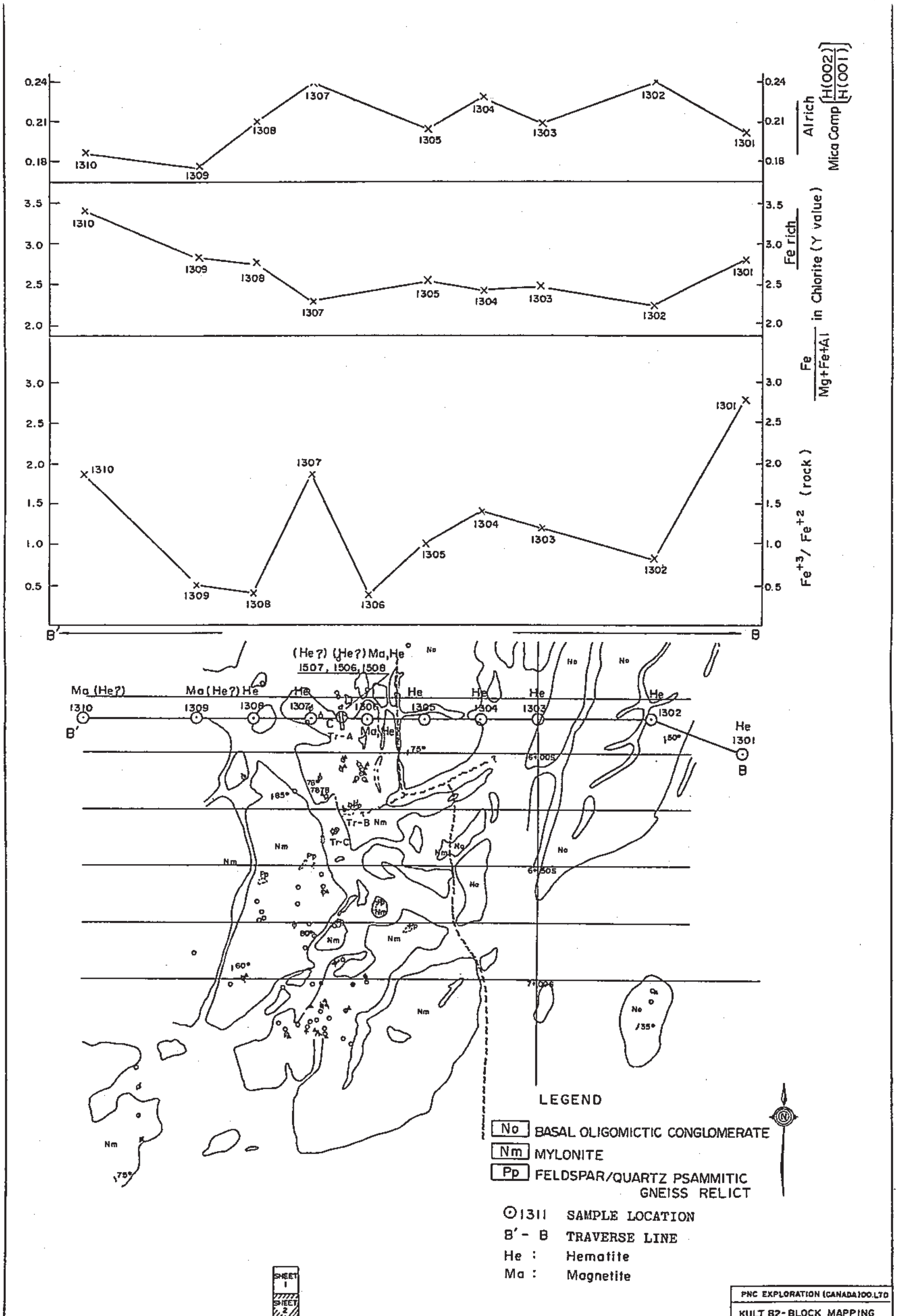
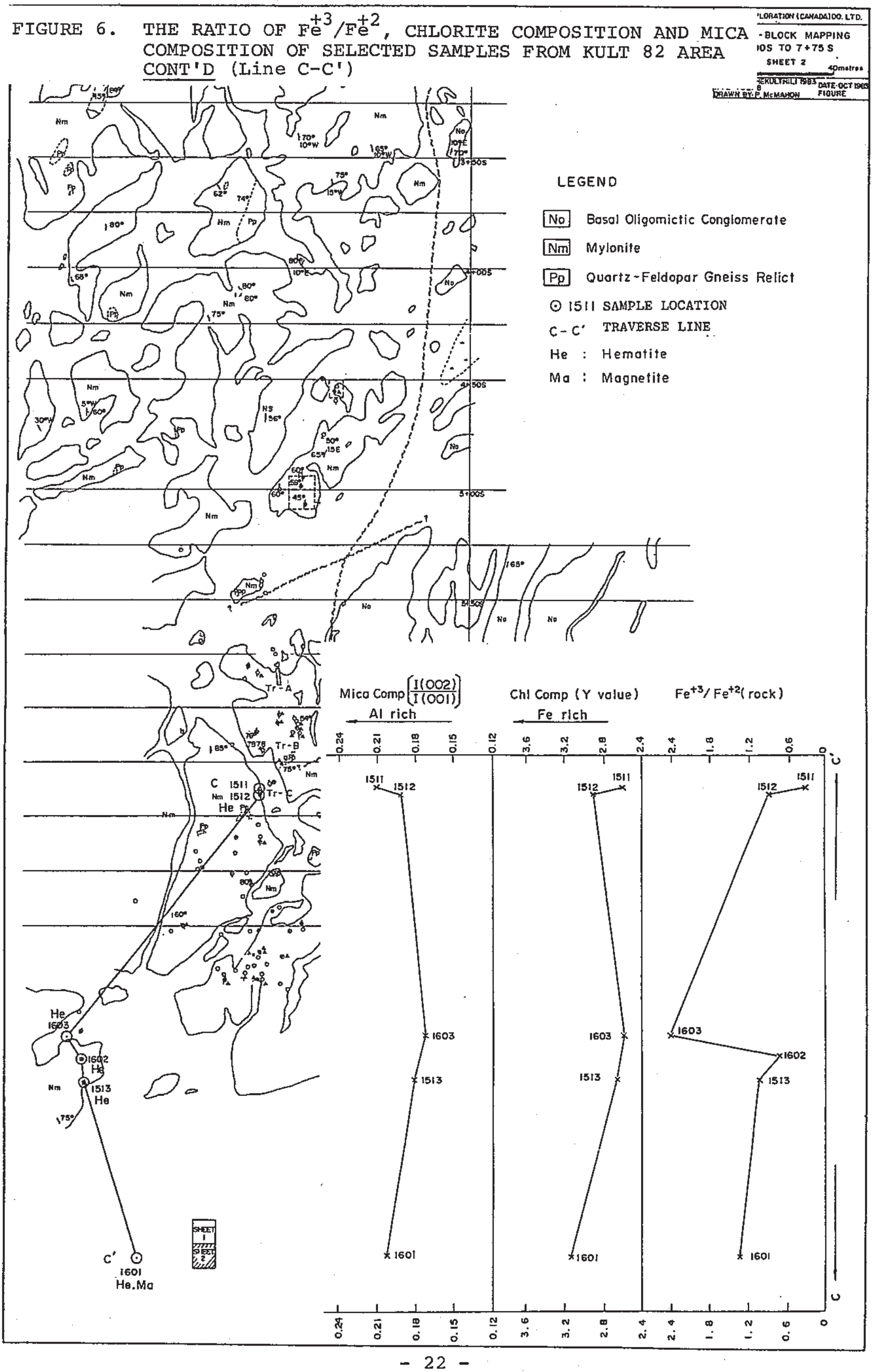


FIGURE 6. THE RATIO OF Fe^{+3}/Fe^{+2}, CHLORITE COMPOSITION AND MICA COMPOSITION OF SELECTED SAMPLES FROM KULT 82 AREA CONT'D (Line B-B')

FIGURE 6. THE RATIO OF Fe^{+3}/Fe^{+2}, CHLORITE COMPOSITION AND MICA COMPOSITION OF SELECTED SAMPLES FROM KULT 82 AREA CONT'D (Line C-C')



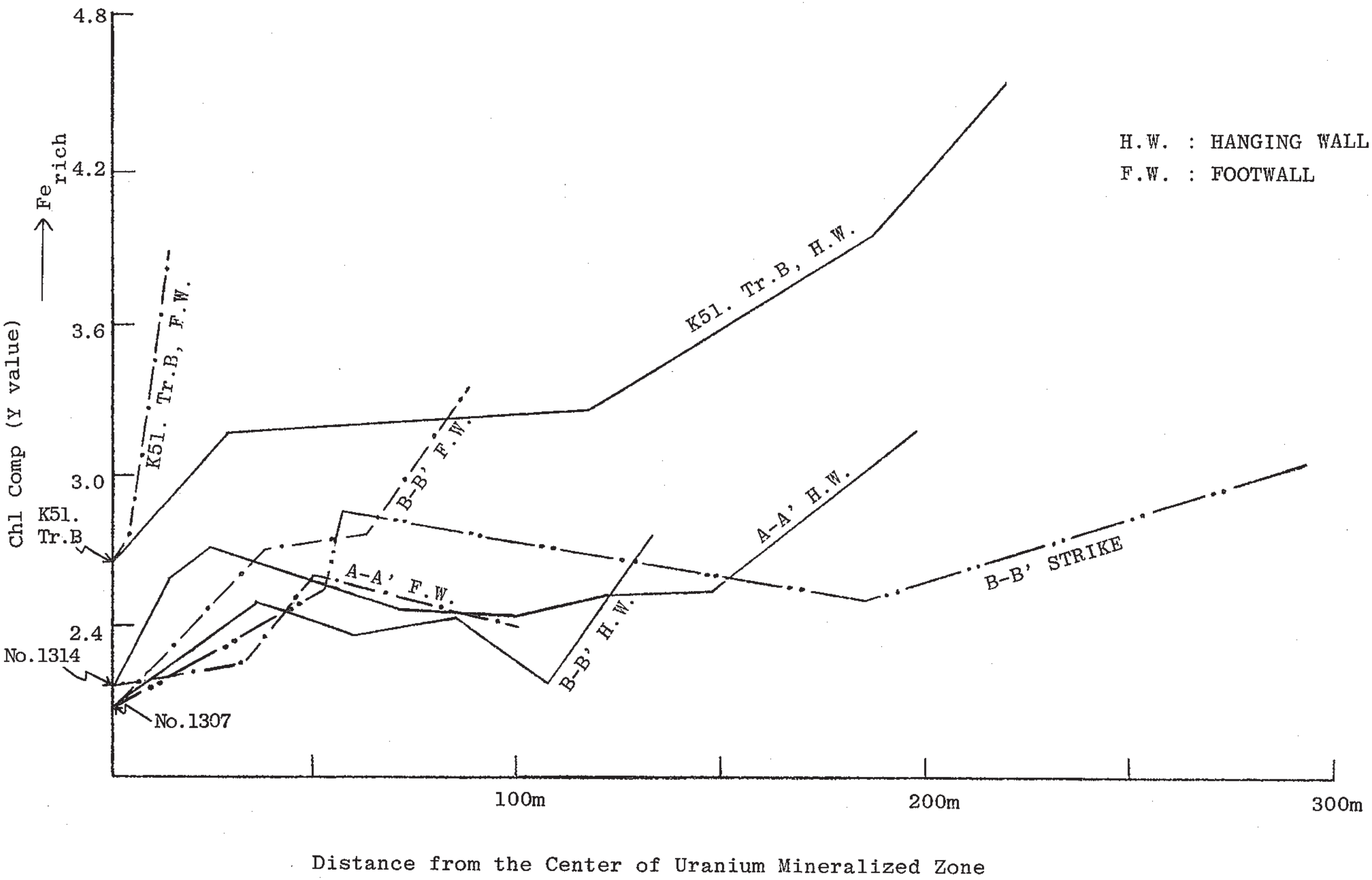


FIGURE 7. VARIATION OF CHLORITE COMPOSITION TO DISTANCE FROM THE CENTER OF URANIUM MINERALIZED ZONE

order, the strike, the hanging wall, and the footwall. In other words, alteration aureole becomes wider in an ascending order, the footwall, the hanging wall, and the strike, in the very rough ratio of 1:3:5.

5. (SAMPLING METHOD) The results hitherto mentioned lead to the idea that a systematic semi-grid sampling elongated along the strike, around the surface expression of the uranium mineralization, is recommended. From the zonal variation of the chlorite and mica compositions, as well as Fe^{+3}/Fe^{+2} ratio of rocks, the outline of a blind ore body could be obtained.

V. AGE DETERMINATION

Tables 3 ∿ 5 show the results of age determinations* and the following considerations are obtained.

1. Kult 13

(1) $^{207}Pb - ^{206}Pb$ age of the pitchblende (TK 13-56, 76.1 m) is 1.88 b.y., which corresponds to the age (1.91 b.y.) of pitchblende from "SF Showing". This fact and a similar mode of occurrence between the two proves that these two manifestations belong to the same episode of uranium mineralization.

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* U-Pb and Rb-Sr analyses by Teledyne Isotopic Laboratories, U.S.A.; K-Ar analyses by Okayama University of Science.

2. Kult 82

(1) K - Ar date of sericite from mylonitic rocks adjacent to Tr. A is 2.24 b.y. Burwash and Baarsgaard (1962) referred such old age to "Survival Value" date which has been established initially during the Kenoran Orogeny and partially updated by the later Hudsonian event. Since the age of mylonitization is still uncertain, further evaluation of the age data is necessary.

3. Kult 59

(1) K - Ar age of hornblende from amphibolite schlieren found in migmatite is 2.16 b.y. Judging from the mode of occurrence of the amphibolite, this date also may represent the "Survival Value".

(2) The Rb - Sr analyses of the samples from Tr. 5 is shown in Table 5. The results show some deviation from perfect isochron behavior beyond the normal analytical uncertainty. This implies either a lack of equilibrium or open system behavior of the minerals in question, probably due to migmatization.

(3) In short, K - Ar age (1.96 b.y.) of hornblende, ^{207}Pb - ^{206}Pb age (1.92 b.y.)* of pitchblende, and K - Ar age (1.76 b.y.) of biotite are obtained in Kult 59 area.

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* ^{207}Pb - ^{206}Pb ages of pitchblende in Tr. 1 and 3 are 1914 and 1934 m.y. respectively (see Appendix, TABLE 4).

(4) It is said that the closure temperature of argon in hornblende is 500 ∿ 550°C, and biotite approximately 300°C (Gerling et al. 1965; Harrinson, 1981). The minimum temperature of migmatization is estimated to the 665°C (Mehnert and Busch, 1982). Using these data, a hypothetical temperature-time relationship in the area is drawn (Figure 7). Interpolation of the pitchblende dates leads to the temperature, 480 ∿ 500°C, of the formation. This value fairly coincides with that of formation of hydrothermal (metamorphic) pitchblende, approximately 500°C, in Beaverlodge area (Sassano et al., 1972).

In conclusion, all the accumulated data as to mode of occurrence of pitchblende, orientation of pitchblende veins and their relationships to petrofabrics, ^{207}Pb - ^{206}Pb dates of pitchblende formation, as well as geological setting firmly demonstrate that the initial uranium mineralization at Kult 59 area must be due to hydrothermal process* in the stage of retrogressive metamorphism belonging to the Hudsonian Movement.

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* Vernon (1976) and Suk (1983) describe that decrease of confining pressure in the period of retrogressive metamorphism makes the rock fissure and fracture and movement of hydrothermal solution more active, resulting in veining of minerals. The hydrothermal solution is perhaps derived from the underlying migmatite body.

TABLE 3. U/Pb AGES OF SOME SELECTED SAMPLES FROM THEKULTHILI LAKE AREA

Sample No.	Location	Host-rock	Analysed Mineral	$^{206}Pb/^{238}U$ (m.y.)	$^{207}Pb/^{235}U$ (m.y.)	$^{207}Pb/^{206}Pb$ (m.y.)
1401	Kult 13 TK13-56, 74.1m	Mylonite	Pitchblende	1248	1490	1884
1407	Kult 13 TK13-58, 71.8m	Mylonite	Pit. b.g. fract.	813	988	1428
0801	Kult 82 Tr.A	Ol. congl. (Sheared)	Pitchblende & Coffinite	740	796	974

TABLE 4. K/Ar AGES OF SOME SELECTED SAMPLES FROM KULT 59 AND 82, THEKULTHILI LAKE AREA

Sample No.	Location	Rock Name	Analysed Mineral	K Content (%)	K/Ar Age (m.y.)
1202	Kult 59 15+00S 23+00W	Amphibolite	Hornblende	1.44	2160±40
1103	Kult 59 Tr.4	Biotite gneisse	Biotite	2.96	1730±20
1105	Kult 59 Tr.5	Hornblende-biotite-gneiss	Hornblende	1.01	1960±60
1105	Kult 59 Tr.5	Hornblende-biotite-gneiss	Biotite	5.31	1780±20
1306	Kult 82 5+85S 0+75W	Mylonite	Sericite + Calcite	4.35	2240±40

TABLE 5. Rb-Sr ANALYSES OF SOME SELECTED SAMPLES FROM KULT 59, THEKULTHILI LAKE AREA

Sample No.	Location	Rock Name	Analysed Fraction	Rb (ppm)	Sr (ppm)	$^{87}Rb/^{86}Sr$	$^{87}Sr/^{86}Sr$
1105	Trench 5	Hornblende-biotite-gneiss	Biotite	483.0	525.2	2.66	0.7754±0.0001
			Hornblende	87.6	493.0	0.51	0.7127±0.0001
			Plagioclase	32.7	463.0	0.20	0.7112±0.0001
			Whole rock	33.8	626.9	0.16	0.7102±0.0001

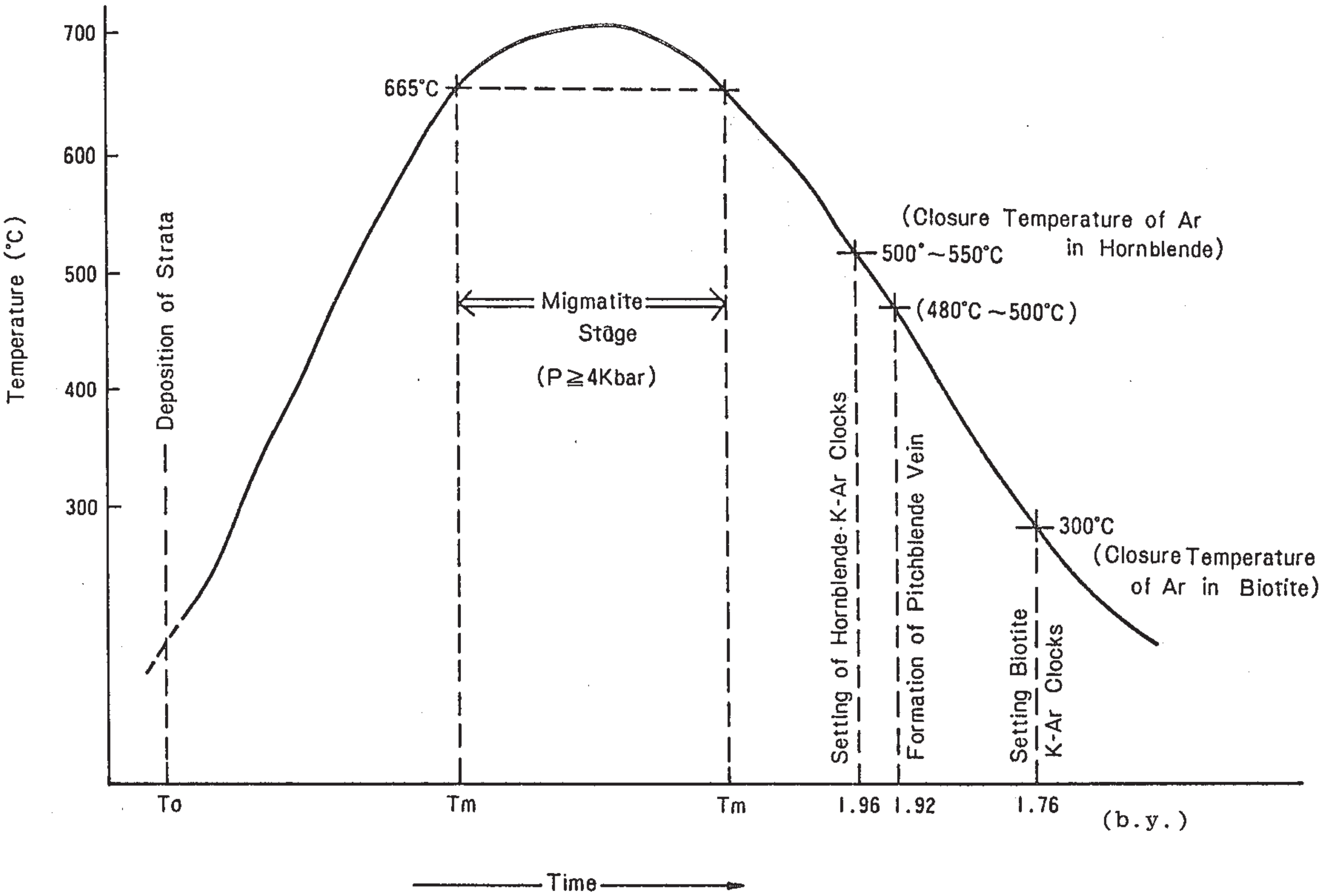

FIGURE 8. HYPOTHETICAL TEMPERATURE-TIME CURVE OF KULT 59 AREA

REFERENCES

Burwash, T.A. and Baadsgaard, H. (1962), Yellowknife-Nonacho Age and Structural Relations. In Stevenson, J.S., Tectonics of the Canadian Shield, Royal Society of Canada, Special Publication, 4, 22-29.

Drummond, J.M. (1964), An Appraisal of Fracture Porosity. Bull. Can. Petr. Geol. 12, 226-245.

Esquevin, J. (1969), In fluence de la Composition Chimique des Illites sur leur Cristallinite. Bull. Centre Rech. Pau-ANPA, 3, 147-153.

Gerling, E.K., Kol'tsova, T.V., Petrov, B.V. and Zul'fikarova, Z.K. (1965), On the Stability of Amphiboles for Age Determination by K-Ar Method. Geochemistry International, 2, 148-154.

Harrison, T.M. (1981), Diffusion of ^{40}Ar in Hornblende. Contr. Mineral. Petrol., 78, 324-331.

Krupicka, J. and Sassano, G.P. (1972), Multiple Deformation of Crystalline Rocks in the Tazin Group, Eldorado Fay Mine, NW Saskatchwan. Can., J. Earth Sci., 9, 422-433.

Mehnert, K.R. and Busch, W. (1982), The Initial Stage of Migmatite Formation. N. Jb. Miner. Abb., 145, 211-238.

Morton, R.D. and Sassano, G.P. (1972), Structural Studies on the Uranium Deposit of the Fay Mine, Eldorado, Northwest Saskatchwan. Can. J. Earth Sci., 9, 803-823.

Sassano, G.P., Fritz, P. and Morton, R.D. (1972) Paragenesis and Isotopic Composition of Some Gangue Minerals from the Uranium Deposits of Eldorado, Saskatchwan. Can. J. Earth Sci., 9, 141-157.

Suk, M. (1983), Petrology of Metamorphic Rocks. Elsevier Sci. Pub. Company. 322pp.

Vernon, R.H. (1976), Metamorphic Processes -- Reactions and Microstructure Development. George Allen and Unwin Ltd. 247pp.

Appendix

MINERALOGICAL AND PETROLOGICAL STUDIES ON THEKULTHILI LAKE PROJECT, N.W.T. CANADA -- THE 1982 REPORT --

Ore Processing Laboratory
Ningyo-toge Works

1. INTRODUCTION

Field survey for mineralogical and petrological studies was carried out from the 12th to the 22nd of August, 1982. This year's work was focused on "North Area" including Kult 51 and Kult 59. Not only PNC claims but also the surrounding area has been investigated in order to clarify some features in common with many uranium occurrences in the area. These results are summarized below.

2. RELATION AMONG THE URANIUM OCCURRENCES, HOST-ROCKS, AND THE ASSOCIATED RADIOACTIVE MINERALS

Many uranium occurrences in the area can be classified into 4 types by the nature of their host-rocks: (a) occurrences in Nonacho Group, (b) those in basement rocks, (c) those in or around intrusive rocks, and (d) those in or around mylonite, as shown in Fig. 1.

Although occurrences in Kult 41 belong to type (b), and those in Kult 51 and Cole Showing belong to type (a), they

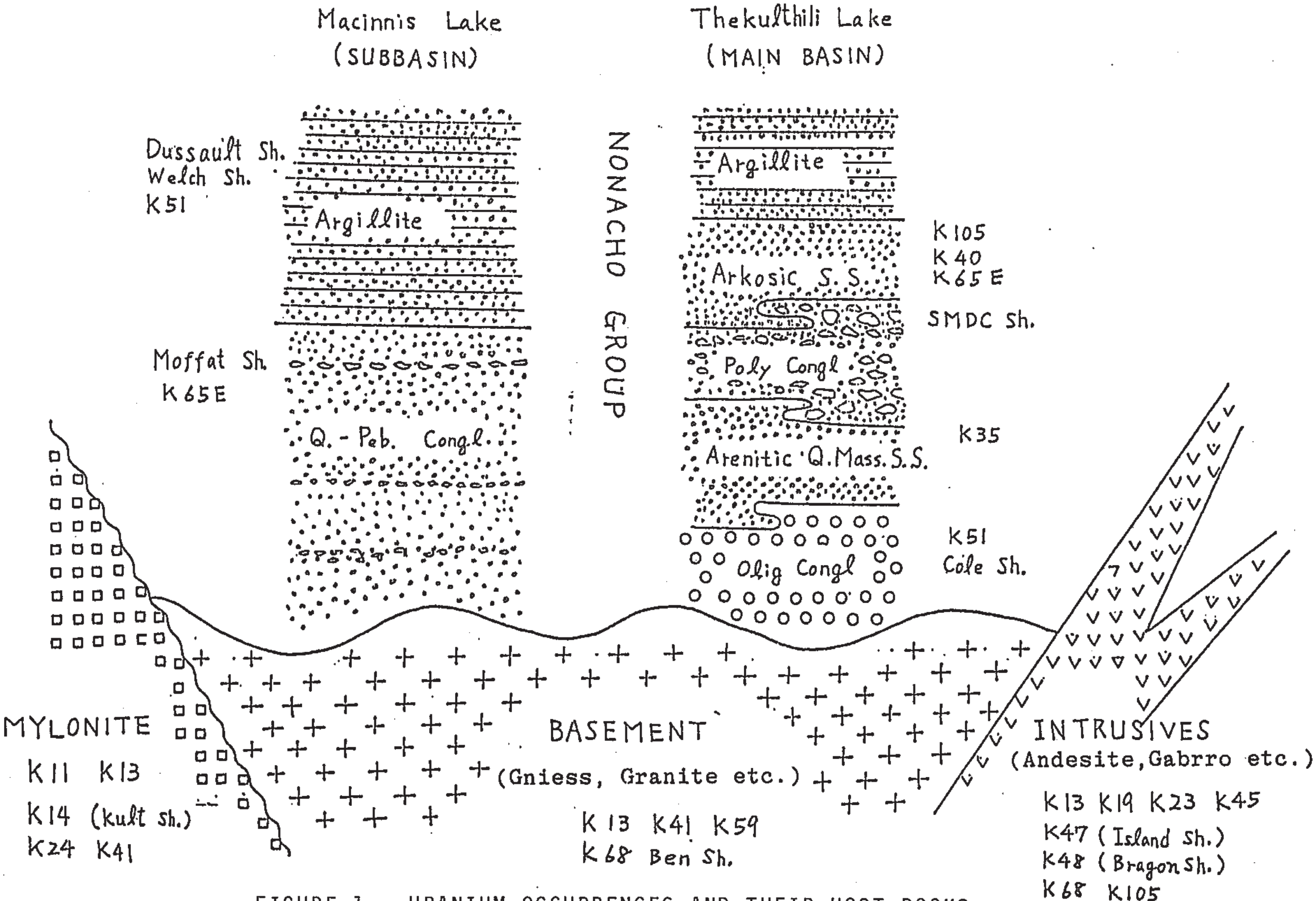

FIGURE 1. URANIUM OCCURRENCES AND THEIR HOST-ROCKS

TABLE 1. CLASSIFICATION OF URANIUM OCCURRENCES IN THEKULTHILI LAKE AREA

No.		Host Rocks	Mode of Occurrences	Examples	Radioactive Minerals	Associated Elements	Continuity (m)	Thickness (cm)	U contents (%)	Veining & Alteration	Defor-mation	Structural Control	Favour-ability
1		Basement Rocks	Vein Veinlet	K13,59,68	Pitchblende Vein Coffinite	(Cu,Pb,Zn)	$10^{1\sim0}$	$10^{2\sim1}$	$10^{1\sim0}$	◎ Q.Cal.Chl. Hem.	⊚	◎ – O	I
2		Mylonite	Veinlet	K11,13,14 24,41	Pitchblende	Cu,Pb,Zn	$10^{2\sim1}$	$10^{3\sim2}$	$10^{1\sim0}$	◎ Chl.Q.Cal.	◎	⊚	I
3		Intrusive Rocks	Disseminated Veinlet	K13,19,23 47,48	Sec.Ur.Min. Pitchblende	Cu,Pb,Zn	$10^{2\sim1}$	10^{1}	$10^{0\sim-1}$	⊚ Chl.Q.Cal.	Δ	O	II
4	Nonacho group	Olig. Congl.	Vein Veinlet	K51 Cole Sh.	Pitchblende Vein		$10^{3\sim2}$	$10^{3\sim2}$	$10^{0\sim-1}$	⊚ Chl.Mag. Hem.	⊚	◎	I
5	Nonacho group	Argillites	Vein Veinlet	K51 Welch.Sh. Dussault Sh.	Pitchblende	Cu,Pb	10^{2}	$10^{2\sim1}$	$10^{0\sim-1}$	O Chl.	O	O – Δ	II
6	Nonacho group	Sandstones	Spot Vein	K35,49,105 SMDC Sh.	Sec.Ur.Min.		$10^{1\sim0}$	$10^{1\sim0}$	$10^{0\sim-1}$	Δ Hem.	Δ	Δ	III
7	Nonacho group	Sandstones (Heavy mineral rich part)	Stratiform	K40 Moffat Sh.	Monazite Zircon	Fe	$10^{1\sim0}$	10^{0}	10^{-2}	X	X	X	III
8	Nonacho group	Red clast (in Poly. Congl.)	Spot	K63,64	Thorite(?)	Th	$10^{0\sim-1}$	10^{0}	10^{-2}	X	X	X	IV
9		Pegmatite	Spot	K35	Thorite(?)	Th	$10^{1\sim0}$	$10^{1\sim0}$	10^{-2}	X	X	X	IV

Sec.Ur.Min: Secondary Uranium Minerals such as Uranophane, Boltwoodite, Kasolite and Soddyite.
Deformation: Folding, Fracturing etc.

◎ ⊚ O Δ X
← Strong (Veining & Alteration, and Deformation)
More suitable (Structural Control)

I II III IV
← Large Favourability

also can be classified as type (d), because of its slightly mylonitized nature of the host-rocks.

These occurrences vary from ones which only secondary mineral is sporadically encountered, to those with pitchblende vein of more than few tens meters long. Their favourability can be inferred from (a) the presence or the absence of pitchblende vein, (b) continuity of the mineralized zone, and (c) degree of alteration associated and/or developments of veining. The results are summarized in Table 1, together with their host-rocks and the associated radioactive minerals.

Most favourable are those found in the slightly mylonitized oligomictic conglomerate and the basement rocks. These "first priority" occurrences tend to be limited within the places, where quartz, calcite and chlorite veinings and hematitization are noticed, and pyrite is commonly present. Quartzose sandstone is less favourable for localization of uranium deposits.

Thus, the lithological character of host-rocks must be controlling the deposition of uranium mineralization.

3. URANIUM MINERALIZATION IN KULT 51

(1) Nature of Uranium Mineralization

In order to reveal the nature of uranium mineralization in Kult 51, systematic sampling was carried out, as shown in Fig. 2. Mineralogical studies have pointed out (s) uranium mineralization is found as chlorite-magnetite (or hematite)-pitchblende(?) veinlet, (b)

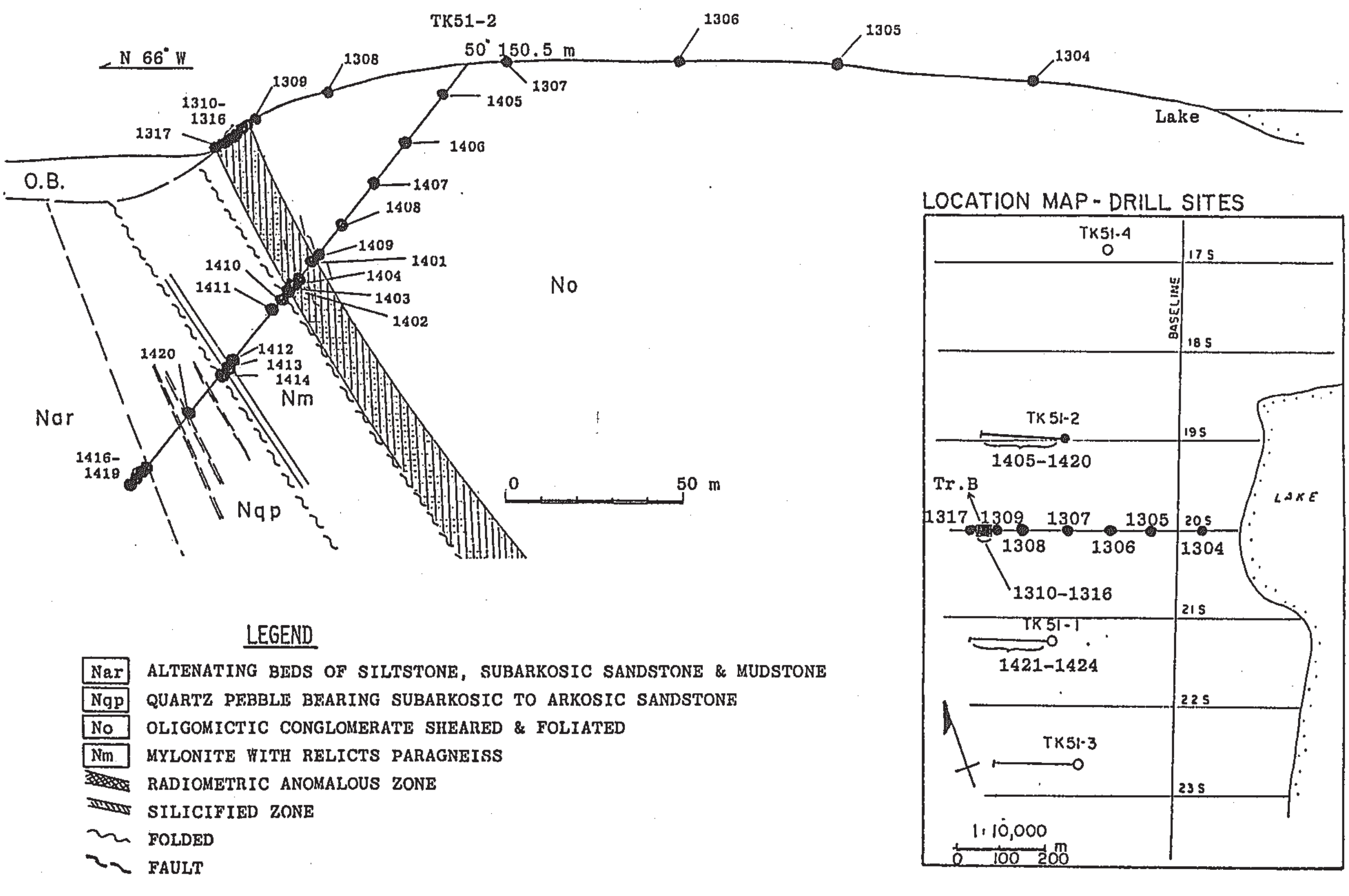

FIGURE 2. LOCATION OF SAMPLES FROM KULT 51 FOR MINERALOGICAL STUDIES

TABLE 2. RESULTS OF MINERALOGICAL STUDIES ON THE SELECTED SAMPLES FROM KULT 51

Sample No.	Location	U_3O_8 ppm	$Fe^{+3}/Fe^{+2'}$	List of Alteration and Metamorphic Minerals								Chl Comp.	Chl Chyst	Ser Crys-tal	Ser/Ch
				Pyr	Hem	Mag	Ser	Bi	Cal	Quart	Chl				
1304	BL20S 0+25E	2	1.13	O			O	O	Δ		O	4.6	0.27	0.30	20
1305	" 0+30W	11	0.62	O			O	O			O	4.0	0.26	0.32	21
1306	" 0+75W	8	0.63	O			O	O	Δ		O	3.3	0.25	0.31	27
1307	" 1+25W	9	0.73	O →	O		O	O	Δ		O	3.3	0.28	0.31	3.2
1308	" 1+75W	12	1.48	O →	O		O		O	Ov	O	3.2	0.26	0.31	5.8
1309	Tr.B 3m East	118	1.17	O →	O		O	O	O		Ov	3.3	0.27	0.29	1.2
1310	Tr.B East End	532	1.67	O →	O		O	O	O		Ov	2.5	0.26	0.26	2.1
1311	Tr.B 1.0m	11	0.47		O		O		Ob	Ov	Ov				
1312	" 1.8m	516	1.47	O	O		O		Ob	O	Ov	4.2	0.25	0.35	1.5
1313	" 3.4m	43	0.75	O	O		O		Ob,v	O	Ov				
1314	" 5.2m	70	1.11	O	O		O		Ob,v	O	Ov				
1315	" 7.0m	105	0.89	O →	O		O		Ob,v	Ov	Ov	3.0	0.25	0.28	4.5
1317	Tr.B 3m West	7	0.92	O →	O		O	O	Ob,v	O	Ov	2.8	0.27	0.27	1.9
1318	BL23S 2+20W											4.3	0.20	0.20	1.2
1405	TK51-2 11.3m Ol.Congl	14	0.46	O	Δ		O			O					
1406	28.0m "	11	0.65						Δ						
1407	42.5m "	9	0.46	O →	O		O		O	O					
1408	57.0m "	5	0.38									2.6	0.25	0.28	7.8
1409	70.1m "	8	1.14												
1401	71.1m Miner.zone	309	0.68	O		O	O				Ov	3.1	0.25	0.29	4.1
1404	77.5m "	165	1.50	O		O	O				Ov	3.4	0.25	0.25	5.8
1403	79.2m "	350	0.83												
1402	79.3m "	234	0.82		O	← O	O		O		Ov	3.6	0.23	0.26	1.9
1410	84.0m "	41	0.79												
1411	91.4m Mylonite	6		O	O							3.9	0.22	0.21	1.2
1413	107.9m Silicified Mylonite	11			O					◎					
1420	124.5m Q.P.Congl	5	5.90												
1416	143.8m Argillite	9			O	← O								0.28	6.50
1418	145.7m "	13													
1421	TK51-1 146.2m Q.P.Congl	6	7.65		O	O									
1423	150.2m Argillite	14	3.12												

$Fe^{+3}/Fe^{+2'}$: Sulfur and ferrous iron contents are allotted for FeS_2, pyrite molecule, and the ratio of the ferric to the remaining ferrous iron contents are calculated.

Pyr: Pyrite, Hem: Hematite, Mag: Magnetite, Ser: Sericite, Bi: Biotite, Cal: Calcite, Quar: Quartz, Chl: Chlorite, b: bent crystal, V: Veinlet,

Δ O ◎ → Rich

Chl Comp: A structural formula of Fe-Mg chlorite is $(Mg,Al)_{6-y}Fe_y(Si,Al)_4O_{10}(OH)_8$, and the value of Y is given as indicating chlorite composition

Arrow(→) indicates Hematitization

Chl Cryst: Chlorite Crystallinity } estimated from FWHM(Full Width at Half Maximum, degree of
Ser Cryst: Sericite Crystallinity } 2θ) of X-ray Diffraction Peak

Ser/Ch: Amount Ratio of Sericite to Chlorite, estimated from Peak Ratio of X-ray Diffraction veinings of quartz, calcite and chlorite tend to develop in the mineralized zone, (c) crystallinity of chlorite and sericite in the zone is slightly higher than those in unmineralized zone, and (d) pyrite grains are commonly present in both the mineralized and unmineralized zones.

(2) Relation between Uranium Mineralization and Magnetic Anomalies

The vertical magnetic gradient survey conducted in summer, 1982 revealed some correlation between magnetic anomalies and uranium mineralization. Laboratory tests have proved that these magnetic anomalies are not due to any particular sedimentary grains but solely to magnetite (or hematite) grains intimately associated with chlorite- pitchblende veinlet. Therefore the magnetic survey in this area is highly recommended to delineate uranium mineralization.

4. URANIUM MINERALIZATION IN KULT 59

Uranium mineralization in Kult 59 is peculiar in the respects as follows;

(a) Pitchblende is rather concentrated in the biotite rich part, where pitchblende is dispersed in the biotite grain boundary or as veinlet and chlorite or chlorite veinlet is not associated.

(b) Calc-silicate gneiss is found in Trench 82-2, and contains grossular, epidote, clinozoisite, zoisite, and monticellite. Feldsparthization is also found in the rock.

5. AGE DETERMINATIONS

Results of K/Ar and U/Pb age determinations are shown in Table 3 and 4, respectively.

These K/Ar dates are all grouped within the middle Hudsonian Orogeny (with exception of No.2014 and 2016, which were slightly altered and appear to have lost Ar).

The oldest uranium mineralization found in the area during this study may be those in Kult 59 and Kult 13. Their apparent age of 1920 m.y. falls within the initial period of the Hudsonian.

TABLE 3. K/Ar AGES OF SOME SELECTED SAMPLES FROM THEKULTHILI LAKE AREA

Sample Number	Location	Rock Name	Analyzed Mineral Fraction	K content (%)	K/Ar age (m.y.)
1301	Kult 51 Tr.C	Argillite	Sericite + Chlorite + Biotite	6.25	1720
1310	Kult 51 Tr.B	Olig. congl.	Sericite + Chlorite + Biotite	7.50	1760
1714	Kult 68 Tr.1	Mylonite	Chlorite + Sericite	1.59	1610
2012	Kult 13 H6 BL35 105S	Mylonite (NS trend)	Chlorite + Sericite	1.12	1810
2014	Kult 13 H6 BL19 40S	Mylonite (NW trend)	Chlorite + Sericite	0.66	1160
2016	Kult 13 TK13 -31, 172.8 m	Mylonite (NS trend)	Chlorite + Sericite	0.25	1360
8501	Kult 13 Tr.1	Granitic R. (Mylonitized)	Feldspar	6.91	1690
8524-1	Kult 13 Tr.3	Para. gn.	Chlorite + Sericite	0.53	1630
8524-2	Kult 13 Tr.3	Para. gn.	Feldspar	4.86	1700
0002	Kult 18 BL650 S100E	Para. gn.	Biotite	5.85	1750

TABLE 4. U/Pb AGES OF SOME SELECTED SAMPLES FROM THEKULTHILI LAKE AREA

Sample No.	Location	Host-rock	Analyzed Mineral	$^{206}Pb/^{238}U$ (m.y.)	$^{207}Pb/^{235}U$ (m.y.)	$^{207}Pb/^{206}Pb$ (m.y.)	Source
8504	Kult 13 Tr.1 (SF Sh.)	Granitic R. (Mylonitized)	Pitchblende	1526	1682	1911	
8521	Kult 13 Tr.2 N.1 (G12.N.1)	Psam. gn.	Pitchblende	913	1189	1761	
8545	Kult 14 Tr.A (Pyr. Sh.)	Mylonite	Pitchblende	991	1125	1184	
1802	Kult 11 Tr.8 (Kult Sh.)	Mylonite	Pitchblende	198	212	383	
2206	Kult 41	Mylonite	Pitchblende	521	578	827	
2201	Kult 59 Tr.82-1	Bi-gneiss	Pitchblende	1714	1792	1914	
1206	Kult 59 Tr.82-3	Bi-gneiss	Pitchblende	1720	1803	1932	
1715	Kult 68 Tr.3	Andesite	Pitchblende	1334	1396	1518	
1716	Kult 68 Tr.2	Amphibolite	Pitchblende	382	429	701	
1310	Kult 51 Tr.B	Ol. congl. (Sheared)	U rich fract.	759	898	1281	
1807	Cole Showing	Ol. congl. (Sheared)	Pitchblende	362	421	775	
2101	Dussault Sh.	Argillite	Pitchblende	160	185	528	
GFA77-16	Dussault Sh.	Argillite	Pitchblende	156	159	196	Gandhi et al. (1980)
GFA78-178	Moffat Sh.	Gr.peb.congl.	U b.g. sample	378	405	560	
LF-71	Ben Claims	Granitic gn.	Pitchblende	221	313	1073	
-27				199	286	1074	
THEK-4	Steave Sh. (SMDC Sh.)	Poly. congl.	Pitchblende	628	891	1671	