13.

LOW GRADE URANIUM MINERALIZATION IN CARBONATE ROCKS FROM SOME SALT DOMES IN THE QUEEN ELIZABETH ISLANDS, DISTRICT OF FRANKLIN

Projects 740081 and 760014

I.R. Jonasson[1] and H.E. Dunsmore[2]

Jonasson, I.R. and Dunsmore, H.E., Low grade uranium mineralization in carbonate rocks from some salt domes in the Queen Elizabeth Islands, District of Franklin; in Current Research, Part A, Geol. Surv. Can., Paper 79-1A, p. 61-70, 1979.

Abstract

A reconnaissance survey was made of parts of the Queen Elizabeth Islands to determine suitable geological settings in which U mineralization might be located. The geological studies were integrated with, and supported by, detailed geochemical studies of stream sediments, waters and rocks.

Two main target types were selected: Paleozoic and Mesozoic continental sandstones on Melville and Ellef Ringnes islands, and Pennsylvanian anhydrite-halite diapirs intruding these sediments at the same locations.

Sandstone did not yield any U occurrences although its potential remains undiminished. However significant signs of radioactivity were encountered within the Dumbbells Dome, Ellef Ringnes Island. These led ultimately to the discovery of extensive, low grade U mineralization hosted by Pennsylvanian limestone breccias. Stream waters analyzed for uranium proved particularly useful in outlining favourable zones, especially when used in detailed studies. Sediments, leached by sulphate-bearing waters, were less effective. However all geochemical and radiochemical methods were found to be restricted by the nature of the generally wet and deeply weathered arctic terrain.

Introduction

The Queen Elizabeth Islands of the high arctic of Canada are underlain primarily by Phanerozoic sedimentary rocks, including thick sequences of continental sandstone and conglomerate. These settings, like similar rocks in Appalachia and the southwestern U.S.A., may host tabular and roll-type uranium ore deposits. The proximity of Shield rocks, including granite, to the east suggests that uranium could have been derived through prolonged weathering of the Precambrian basement rocks and concentrated at suitable settings within younger sedimentary strata.

Other exploration targets are the piercement diapirs of Pennsylvanian gypsum, anhydrite, halite, and various carbonate rocks which have intruded younger rocks, including Cretaceous sandstone and shale. Frequently, the diapirs themselves are intruded by basic igneous rocks in the form of diabase sills, dykes, and ring dykes. An association between marine evaporites and uranium mineralization has been observed in Atlantic Canada, with concentrations found in sandstone on the flanks of diapirs and in carbonate at the base of the evaporitic sequence. There are about 100 diapirs in the Queen Elizabeth Islands with most located on Axel Heiberg and the Ringnes islands. Some of these structures have been found to trap natural gas on their flanks.

It was decided to confine our initial field investigations to a brief survey of selected Mesozoic and Paleozoic rocks on Eastern Melville Island, including the Barrow Dome; and to Mesozoic rocks in the vicinity of the Dumbbells Dome, Ellef Ringnes Island. The results of these surveys are presented here.

Generalized Geology and Sample Locations

The simplified geology of Ellef Ringnes Island is presented in Figure 13.1 (after Stott, 1967) on which Dumbbells Dome is marked "D" and Isachsen Dome, which lies to the southwest but was not visited, is marked "I". Figure 13.2 is a simplified geological map of the Weatherall Bay area of eastern Melville Island (after Tozer and Thorsteinsson, 1964) showing sample locations resulting from foot traverses. Sample locations for Dumbbells Dome are shown on Figure 13.3. These samples were taken during traverses using a Honda ATC-90 autobike.

Analytical Methods

Uranium was analyzed in waters by fluorometry (Geological Survey of Canada, GSC) and in sediments by delayed neutron activation (Atomic Energy of Canada Ltd., AECL). All other analyses on waters were made by standard methods in use at GSC; sediment analyses were provided by Chemex Ltd., Vancouver. Rock analyses for U were made by AECL. Table 13.1 summarizes the analytical methods used.

Geochemical Studies – Melville Island

Waters

Results are presented in Table 13.3 for water samples collected from the Weatherall Bay area (78G-H) and from the Barrow Dome gypsum diapir (79B). Table 13.2a gives the location of the samples.

It is immediately apparent that our limited sampling program did not detect any high U levels in waters draining Paleozoic sandstone and conglomerate around Weatherall Bay. The pH values of all but one water (sample 7) were neutral or slightly alkaline, and this single sample was significant only for a small quantity of Zn (1.7 ppb). Salt contents, i.e., Na, K, Cl, F, Ca, $SO_4^{=}$, were found to be quite low. pH is probably controlled by small amounts of dissolved calcium carbonate, precipitates and cements of which are commonly observed in the area.

However, samples from two of the three streams which cut the Barrow Dome diapir contained small amounts of dissolved U and substantial quantities of Ca and $SO_4^{=}$ ions, as might be anticipated. We do not view these data as unusual, although similar levels found in similar terrain on Ellef Ringnes Island suggest that a closer look at Barrow Dome rocks would be in order.

[1] Resource Geophysics and Geochemistry Division
[2] Regional and Economic Geology Division

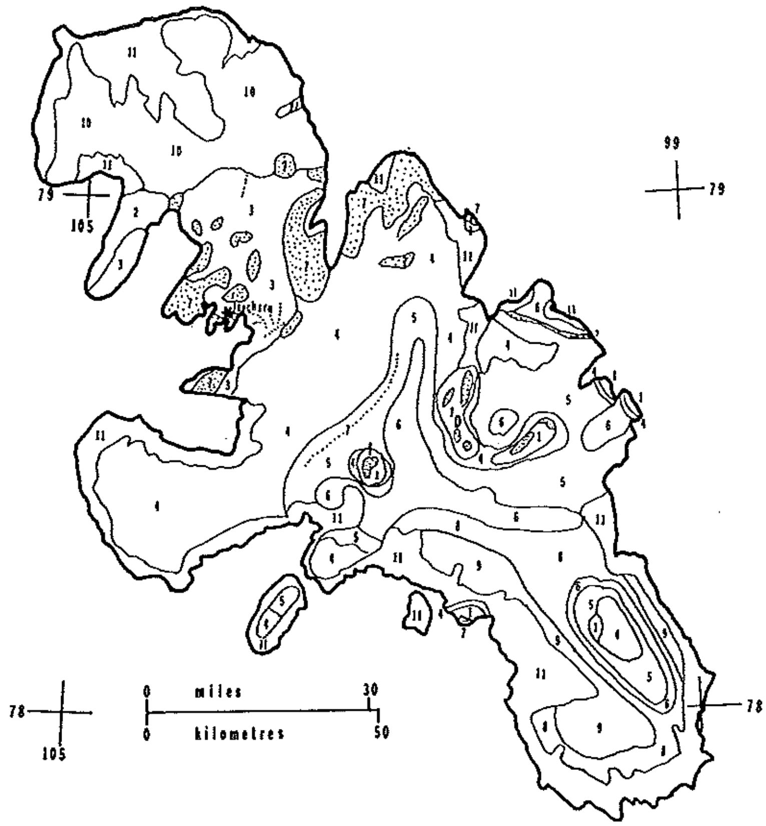


Figure 13.1. Simplified geology of Ellef Ringnes Island (after Stott, 1967) (D = Dumbbells Dome, I = Isachsen Dome).

LEGEND

(Figures 13.1 and 13.3)

11. PLEISTOCENE AND RECENT: alluvial and deltaic sand, marine beach deposits.
10. TERTIARY: Beaufort Formation; nonmarine sands and gravels, fossil wood.
9. UPPER CRETACEOUS and TERTIARY: Eureka Sound. Formation; sandstone, siltstone, shale, sand, and lignite.
8. UPPER CRETACEOUS: Kanguk Formation; dark grey marine shale, siltstone.
7. LOWER and UPPER CRETACEOUS: diabase, gabbro sills, dykes.
6. LOWER and UPPER CRETACEOUS: Hassel Formation; sand and sandstone, shale, coal.
5. LOWER CRETACEOUS: Christopher Formation; grey to black shale, minor siltstone and limestone.
4. LOWER CRETACEOUS: Isachsen Formation; sandstone, sand, shale, coal.
3. UPPER JURASSIC and LOWER CRETACEOUS: Deer Bay Formation; dark grey and black marine shale.
2. JURASSIC: Savik Formation; grey marine shale. Borden Island Formation; white sandstone, siltstone. Jaeger Formation; green, glauconitic and ferruginous sandstone.
1. CARBONIFEROUS: gypsum, anhydrite; limestone, limestone breccia

- • geochemical sample
- x rock sample
- c carbonate

LEGEND

(Figure 13.2)

15. PERMIAN: Assistance Formation; green, grey and dusky red sandstone, grey limestone; marine.
14. LOWER PERMIAN: Sabine Bay Formation; green and grey calcareous sandstone, limestone.
12. PENNSYLVANIAN: Canyon Fiord Formation; red, brown, and orange sandstone, conglomerate.
11. UPPER DEVONIAN: Griper Bay Formation; green, grey, white carbonaceous sandstone, siltstone, shale, thin coal seams.
10. UPPER DEVONIAN: Hecla Bay Formation; white, yellow, red nonmarine sandstone.
9. MIDDLE DEVONIAN: Weatherall Formation; grey marine and nonmarine sandstone, shale, siltstone.
8. MIDDLE DEVONIAN: Blue Fiord Formation; grey limestone.
7. SILURIAN: grey dolomite.

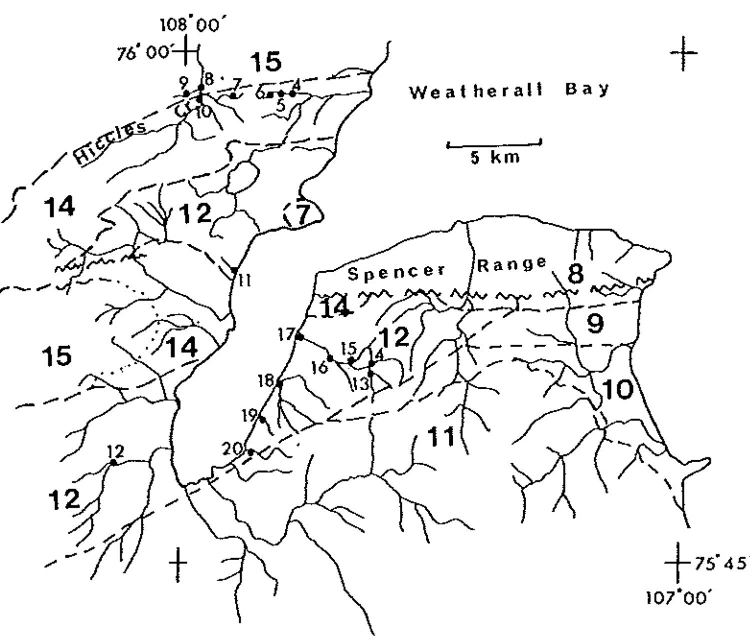
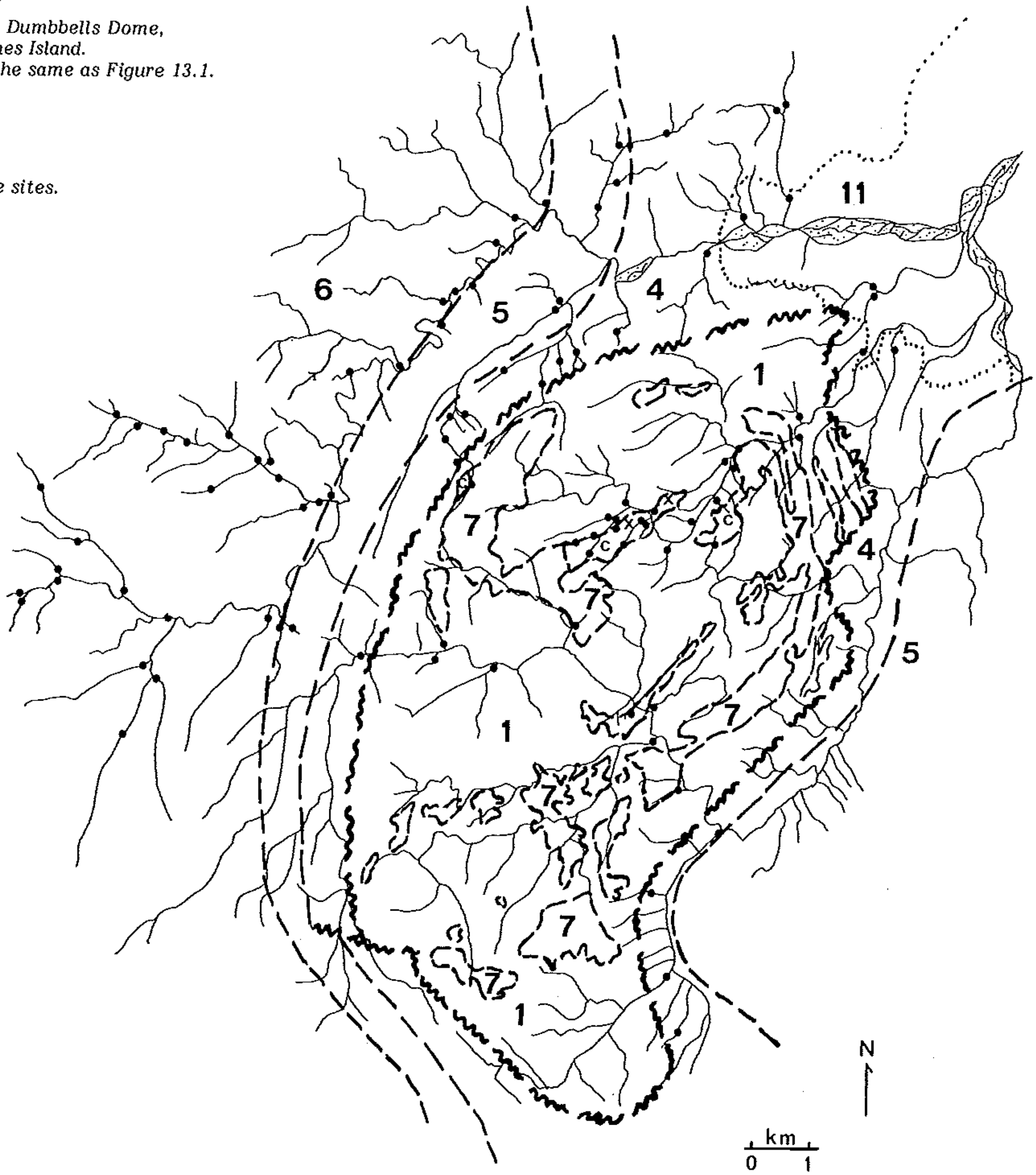


Figure 13.2. Geology and sample locations, Weatherall Bay area, Melville Island.

Figure 13.3

Geology of Dumbbells Dome, Ellef Ringnes Island. Legend is the same as Figure 13.1.

• *Sample sites.*



Sediments

Results are presented in Table 13.4 for sediment samples collected in the same areas noted above. In contrast to water data (Table 13.3), some low level anomalies for U were found in streams draining the Griper and Sabine Bay formations. Small amounts of Zn and Ni accompany U. A realistic assessment of the significance of these values cannot be made in view of the limited data.

On the other hand, the conclusion that the Barrow Dome diapir is worth further investigation is substantiated by the presence of small amounts of U, Zn, Cu, and Ni in three stream sediments collected there. A little Mo is also present. Similar element groupings were observed in sediments collected from a uraniferous area in Dumbbells Dome (69F).

Geochemical Studies — Ellef Ringnes Island

Waters

Results are presented in Table 13.3 for water samples collected on and around the Dumbbells Dome diapir (69F). Table 13.2b gives the locations of the samples.

Table 13.1

Analytical methods

(a) Waters

Entity	Method	Detection Limit	Remarks
pH	pH meter		± 0.02
Cl^-	colorimetry	1.0 ppm	thiocyanate
Na	atomic absorption	100 ppb	direct aspiration
K	atomic absorption	100 ppb	direct aspiration
$SO_4^=$	colorimetry	10 ppm	barium titration
Ca	atomic absorption	100 ppb	direct aspiration
Mg	atomic absorption	100 ppb	direct aspiration
Zn	atomic absorption	1.0 ppb	APDC-MIBK extraction
Cu	atomic absorption	1.0 ppb	APDC-MIBK extraction
F^-	ion sensitive electorde	40 ppb	–
U	fluorometry	0.10 ppb	–

(b) Sediments and Rocks

Entity	Method	Detection Limit	Remarks
U	neutron activation	0.1 ppm	
Zn	atomic absorption	1 ppm	conc HNO_3 - HCl
Cu	atomic absorption	1 ppm	conc HNO_3 - HCl
Pb	atomic absorption	2 ppm	conc HNO_3 - HCl
Ni	atomic absorption	1 ppm	conc HNO_3 - HCl
Co	atomic absorption	1 ppm	conc HNO_3 - HCl
Ag	atomic absorption	0.1 ppm	conc HNO_3 - HCl
Mn	atomic absorption	1 ppm	conc HNO_3 - HCl
Fe	atomic absorption	1 ppm	conc HNO_3 - HCl
Ba	atomic absorption	10 ppm	conc HNO_3 - HCl
Mo	atomic absorption	1 ppm	conc HNO_3 - HCl
W	colorimetry	2 ppm	fusion
Hg	atomic absorption	20 ppb	cold vapour

As in the case for the streams draining similar sandstone formations on Melville Island, streams outside the dome (units 4, 5, 6; Fig. 13.3) are generally low in U. There are some exceptions and these lie to the north of the dome (samples 46, 47) within the Isachsen Formation (Fig. 13.1) near its contact with overlying Christopher shale. Samples 54-62 from another group of streams draining Isachsen sandstone on the western limits of the dome and some gypsum masses also contain dissolved U up to 2.50 ppb with an average around 0.70 ppb. It is difficult to decide, on this evidence, whether the main source of U is sandstone, evaporite, or both. Elsewhere, in the Hassel sandstone, which like the Isachsen, is coaly in places, U levels are low at around 0.05 ppb. These values should be regarded as typical for waters draining these formations. Streams draining more erosion resistant Christopher shale are commonly dry.

Within the Dumbbells Dome complex significantly higher U levels were measured. Tributaries (samples 2-10) of a major arm of the East Dumbbells River, which bisects the Dome carried dissolved U in the range 0.05 – 3.05 ppb. Another fork to the north, draining the core of the Dome (samples 64-68; 83-97) comprising limestone breccias and gypsum, also carried similar quantities of dissolved U.

U anomalies in the study area fall into two categories. One is characterized by waters high in dissolved Ca, $SO_4^=$, Mg and F. Clearly, the chemistry is controlled by gypsum with Ca levels moderated by calcium carbonate. A few hand specimens of crystalline and massive gypsum were found to contain thin seams of fluorite and thus the presence of F in the waters is readily explained. These samples also carry a little U (site 66, Table 13.5).

The second group of U anomalies is characterized by waters containing appreciably more Na, K, and Cl, but less Ca and $SO_4^=$. F is present, as is Mg, in similar quantities in both groups.

Each category contains occasional high values of Zn; sample 24 reached 628 ppb Zn in an acid stream water draining coaly sandstone and coal seams of the Hassel Formation. Others (samples 38, 73) contain dissolved Zn around 40 ppb, and these too drain coaly sandstone (Fig. 13.3). Zn levels of 2.0-4.0 ppb were measured in certain stream waters within the salt dome. Low Cu values (1.0 – 4.0 ppb) were found rarely, usually in streams draining Hassel sandstone.

One small group of water samples (52-62) appears to receive contributions of U from both coaly sandstone (Isachsen Formation) and massive gypsum outcrop. The chemistry reflects this; the waters carry high levels of Cl, Na, K, $SO_4^=$, Ca, Mg, and F (Table 13.3b).

The pH of all water samples is generally close to 8.0; occasional low levels, as noted above, are around 4.4. We consider that the former are controlled by carbonate buffering, whereas the latter are effected by oxidizing pyrite or other iron sulphides within the coal seams. Moreover, it is likely that the small amounts of Cu and Zn owe their origins to iron sulphides in coal (Hassel and Isachsen) and in pyritic limestone breccias found within the Dome.

Sediments

Results of analyses of sediment samples collected at the same sites described above (69F) and in Table 13.2b are presented in Table 13.4.

Table 13.2

Stream sediment and water sample locations

a) Melville Island, District of Franklin

NTS	SAMPLE NUMBER	ZONE UTM	COORDINATES EAST NORTH	BEDROCK TYPE	GEOLOGICAL FORMATION
78G	770012	12	5783008414800	CGLM	CANYON FJORD FM
78H	770002	13	4555008379500	SNDS	GRIPER FM
78H	770003	13	4564008379900	SNDS	GRIPER FM
78H	770004	13	4246008434600	SNDS	SABINE BAY FM
78H	770005	13	4242008434500	SNDS	SABINE BAY FM
78H	770006	13	4237008434500	SNDS	SABINE BAY FM
78H	770007	13	4214008434200	SNDS	SABINE BAY FM
78H	770008	13	4196008434700	SNDS	SABINE BAY FM
78H	770009	13	4193008434500	SNDS	SABINE BAY FM
78H	770010	13	4195008434300	SNDS	SABINE BAY FM
78H	770011	13	4212008425100	SNDS	CANYON FJORD FM
78H	770013	13	4286008418800	SNDS	CANYON FJORD FM
78H	770014	13	4278008419200	CGLM	CANYON FJORD FM
78H	770015	13	4276008419300	SNDS	CANYON FJORD FM
78H	770016	13	4264008419600	CGLM	CANYON FJORD FM
78H	770017	13	4255008420400	SNDS	CANYON FJORD FM
78H	770018	13	4237008418700	SNDS	CANYON FJORD FM
78H	770019	13	4226008416800	SNDS	CANYON FJORD FM
78H	770020	13	4216008414900	SNDS	CANYON FJORD FM
79B	770014	12	5495008505400	GPSM	BARROW DOME, OTTO FJORD FM
79B	770015	12	5497008505900	GPSM	BARROW DOME, OTTO FJORD FM
79B	770016	12	5498008506200	GPSM	BARROW DOME, OTTO FJORD FM

b) Ellef Ringnes Island, District of Franklin

NTS	SAMPLE NUMBER	ZONE UTM	COORDINATES EAST NORTH	BEDROCK TYPE	GEOLOGICAL FORMATION
69F	770002	14	4455008724700	SNDS	ISACHSEN FM
69F	770003	14	4458008725100	GPSM	DUMBELLSDOME, OTTO FJORD FM
69F	770004	14	4472008725400	GPSM	DUMBELLSDOME, OTTO FJORD FM
69F	770005	14	4475008725000	GPSM	DUMBELLSDOME, OTTO FJORD FM
69F	770006	14	4488008726200	GBBR	DUMBELLSDOME
69F	770007	14	4504008725100	GBBR	DUMBELLSDOME
69F	770008	14	4507008725400	GBBR	DUMBELLSDOME
69F	770009	14	4509008724800	GBBR	DUMBELLSDOME
69F	770010	14	4516008724200	GBBR	DUMBELLSDOME
69F	770011	14	4526008723500	SNDS	ISACHSEN FM
69F	770012	14	4523008723100	SNDS	ISACHSEN FM
69F	770013	14	4519008722100	SNDS	ISACHSEN FM
69F	770014	14	4525008720300	SNDS	ISACHSEN FM
69F	770015	14	4528008719700	BCKS	ISACHSEN FM
69F	770016	14	4434008727400	SNDS	HASSEL FM
69F	770017	14	4434008727200	SNDS	HASSEL FM
69F	770018	14	4430008727000	SNDS	HASSEL FM
69F	770019	14	4423008727200	SNDS	HASSEL FM
69F	770020	14	4421008727500	SNDS	HASSEL FM
69F	770022	14	4418008727500	SNDS	HASSEL FM
69F	770023	14	4414008726800	SNDS	HASSEL FM
69F	770024	14	4411008727800	SNDS	HASSEL FM
69F	770025	14	4405008727400	CLSD	HASSEL FM
69F	770026	14	4400008727400	CLSD	HASSEL FM
69F	770027	14	4394008727400	SNDS	HASSEL FM
69F	770028	14	4388008727400	SNDS	HASSEL FM
69F	770029	14	4385008725300	SNDS	HASSEL FM
69F	770030	14	4394008725100	SNDS	HASSEL FM
69F	770031	14	4389008724300	SNDS	HASSEL FM
69F	770032	14	4390008724000	CLSD	HASSEL FM
69F	770033	14	4385008723500	SNDS	HASSEL FM
69F	770034	14	4383008723600	SNDS	HASSEL FM
69F	770035	14	4403008724300	SNDS	HASSEL FM
69F	770036	14	4412008724100	SNDS	HASSEL FM
69F	770037	14	4410008723000	SNDS	HASSEL FM
69F	770038	14	4412008721700	SNDS	HASSEL FM
69F	770039	14	4416008722800	SNDS	HASSEL FM
69F	770040	14	4430008724700	SNDS	HASSEL FM
69F	770042	14	4434008724600	BCKS	CHRISTOPHER FM
69F	770043	14	4435008725300	BCKS	CHRISTOPHER FM
69F	770044	14	4466008934100	BCKS	CHRISTOPHER FM
69F	770045	14	4469008734800	SNDS	ISACHSEN FM
69F	770046	14	4469008735900	BCKS	CHRISTOPHER FM
69F	770047	14	4471008735700	SNDS	ISACHSEN FM
69F	770048	14	4481008736400	SNDS	HASSEL FM
69F	770049	14	4490008738600	SNDS	HASSEL FM
69F	770050	14	4493008737800	SNDS	ISACHSEN FM
69F	770051	14	4499008735300	SNDS	ISACHSEN FM
69F	770052	14	4491008735000	SNDS	ISACHSEN FM
69F	770053	14	4489008733800	SNDS	ISACHSEN FM
69F	770054	14	4475008732300	SNDS	ISACHSEN FM
69F	770055	14	4469008731300	SNDS	ISACHSEN FM
69F	770056	14	4469008731000	SNDS	ISACHSEN FM
69F	770057	14	4471008730300	SNDS	ISACHSEN FM
69F	770058	14	4464008729800	SNDS	ISACHSEN FM
69F	770059	14	4456008729100	SNDS	ISACHSEN FM
69F	770060	14	4454508728900	SNDS	ISACHSEN FM
69F	770062	14	4457008728650	SNDS	ISACHSEN FM
69F	770063	14	4458008728750	SNDS	ISACHSEN FM
69F	770064	14	4487008727900	GPSM	DUMBELLSDOME, OTTO FJORD FM
69F	770065	14	4485508728100	GPSM	DUMBELLSDOME, OTTO FJORD FM
69F	770066	14	4485008727900	LMSN	DUMBELLSDOME, OTTO FJORD FM
69F	770067	14	4486508728300	LMSN	DUMBELLSDOME, OTTO FJORD FM
69F	770068	14	4493008728600	LMSN	DUMBELLSDOME, OTTO FJORD FM
69F	770069	14	4430008729700	SNDS	HASSEL FM
69F	770070	14	4438008730100	SNDS	HASSEL FM
69F	770071	14	4445508730800	BCKS	CHRISTOPHER FM
69F	770072	14	4445008731100	SNDS	HASSEL FM&BCKS
69F	770073	14	4442508731500	SNDS	HASSEL FM
69F	770074	14	4447508732000	BCKS	CHRISTOPHER FM
69F	770075	14	4952008732800	BCKS	CHRISTOPHER FM
69F	770076	14	4450008733350	SNDS	HASSEL FM
69F	770077	14	4456008733850	BCKS	CHRISTOPHER FM
69F	770078	14	4462008732100	BCKS	CHRISTOPHER FM
69F	770079	14	4463008731800	SNDS	HASSEL FM&BCKS
69F	770082	14	4474008729500	LMSN	DUMBELLSDOME, OTTO FJORD FM
69F	770083	14	4492008728000	GPSM	DUMBELLSDOME, OTTO FJORD FM
69F	770084	14	4485508728100	LMSN	DUMBELLSDOME, OTTO FJORD FM
69F	770085	14	4485508728100	LMSN	DUMBELLSDOME, OTTO FJORD FM
69F	770086	14	4486508728300	LMSN	DUMBELLSDOME, OTTO FJORD FM
69F	770087	14	4485008728500	LMSN	DUMBELLSDOME, OTTO FJORD FM
69F	770088	14	4489508729100	GPSM	DUMBELLSDOME, OTTO FJORD FM
69F	770089	14	4493008728600	LMSN	DUMBELLSDOME, OTTO FJORD FM
69F	770090	14	4494008728950	LMSN	DUMBELLSDOME, OTTO FJORD FM
69F	770091	14	4500008728200	LMSN	DUMBELLSDOME, OTTO FJORD FM
69F	770092	14	4508008728900	LMSN	DUMBELLSDOME, OTTO FJORD FM
69F	770093	14	4502008729850	LMSN	DUMBELLSDOME, OTTO FJORD FM
69F	770094	14	4502508729400	GPSM	DUMBELLSDOME, OTTO FJORD FM
69F	770095	14	4504008730100	LMSN	DUMBELLSDOME, OTTO FJORD FM
69F	770096	14	4506508730150	LMSN	DUMBELLSDOME, OTTO FJORD FM
69F	770097	14	4504508730550	LMSN	DUMBELLSDOME, OTTO FJORD FM
69F	770098	14	4517008731100	GBBR	DUMBELLSDOME
69F	770099	14	4514008731450	GBBR	DUMBELLSDOME
69F	770100	14	4524008733050	BCKS	DUMBELLSDOME, OTTO FJORD FM
69F	770102	14	4526508732950	SNDS	DUMBELLSDOME, OTTO FJORD FM
69F	770103	14	4521008734100	BCKS	CHRISTOPHER FM
69F	770104	14	4519008734300	BCKS	CHRISTOPHER FM

Table 13.3

Analytical Data: Water Samples

a) Melville Island, District of Franklin

Sample number		pH	ppm Cl-	ppm Na	ppm K	ppm SO_4^{2}	ppm Ca	ppm Mg	ppb Zn	ppb Cu	ppb F-	ppb U
78H	770002	7.08	0.6	0.5	0.4	.10	1.6	0.6	2.2	1.0	59	0.05
78H	770003	6.73	0.6	0.3	0.2	.10	1.1	0.3	0.5	0.5	51	0.05
78H	770004	8.31	0.7	2.4	0.9	.23	32.9	2.9	0.5	0.5	62	0.05
78H	770006	8.25	0.8	3.3	1.1	.33	27.4	3.7	0.5	0.5	59	0.05
78H	770007	5.96	0.5	1.6	1.4	.38	5.6	3.6	1.7	0.5	38	0.05
78H	770008	8.06	0.5	1.5	0.5	.25	21.0	1.9	0.5	0.5	50	0.26
78H	770009	8.21	0.5	2.7	0.7	.21	29.0	3.0	0.5	0.5	59	0.05
78H	770010	8.14	0.5	1.8	0.7	.23	26.3	2.8	0.5	0.5	56	0.05
78H	770011	8.12	0.5	6.2	0.5	.10	14.1	1.6	0.5	0.5	59	0.05
78H	770013	7.69	0.8	0.2	0.6	.21	9.6	1.8	0.5	0.5	54	0.05
78H	770014	8.15	0.5	0.4	0.8	.24	22.0	2.8	0.5	0.5	65	0.05
78H	770015	8.28	1.4	0.9	0.8	.10	23.0	3.5	0.5	0.5	62	0.26
78H	770016	7.87	0.9	0.4	0.4	.36	16.7	3.8	0.5	0.5	59	0.05
78H	770017	8.27	4.2	3.1	1.3	.8	24.4	4.4	0.5	0.5	56	0.05
78H	770018	7.67	1.6	0.8	0.7	.14	16.1	2.7	0.5	0.5	59	0.05
78H	770019	7.86	3.5	1.7	1.0	.10	12.7	2.1	0.5	0.5	51	0.05
78H	770020	7.74	6.3	3.7	4.5	.10	8.4	2.7	0.5	0.5	54	0.10
78G	770012	7.50	0.5	0.2	0.9	.10	4.7	2.0	0.5	0.5	51	0.05
79B	770014	8.01	0.5	0.6	0.6	.10	17.7	2.0	0.5	0.5	44	0.10
79B	770015	8.04	3.3	2.5	0.6	6.74	220.4	8.7	0.5	0.5	46	1.35
79B	770016	8.05	3.4	3.1	0.9	6.44	199.7	9.3	0.5	0.5	51	1.40

b) Ellef Ringnes Island, District of Franklin

Sample number		pH	ppm Cl-	ppm Na	ppm K	ppm SO_4^{2}	ppm Ca	ppm Mg	ppb Zn	ppb Cu	ppb F-	ppb U
69F	770002	7.90	5.3	4.0	1.4	736	166.9	26.0	0.5	0.5	100	1.13
69F	770003	7.89	2.0	1.5	1.2	1420	534.7	6.3	2.9	0.5	100	2.70
69F	770004	7.85	1.0	0.6	0.4	1204	453.5	7.6	24.2	0.5	130	2.70
69F	770005	8.12	2.9	2.6	0.7	1380	509.4	9.8	0.5	0.5	141	1.95
69F	770006	7.78	1.1	1.0	0.4	430	188.7	2.9	0.5	0.5	72	0.81
69F	770008	8.01	0.6	0.6	0.5	648	325.3	5.2	0.5	0.5	62	0.81
69F	770009	8.16	4.6	3.3	0.6	1162	448.7	10.4	0.5	0.5	100	1.80
69F	770010	7.89	1.9	1.0	0.2	57	31.9	1.6	0.5	0.5	54	0.05
69F	770011	8.18	6.4	4.9	0.8	840	393.2	12.2	0.5	0.5	108	1.40
69F	770012	8.04	7.7	6.1	0.8	1716	567.2	20.0	0.5	0.5	163	3.05
69F	770013	8.15	3.2	2.3	0.8	1380	528.5	10.9	0.5	0.5	130	2.30
69F	770014	7.92	5.6	3.5	0.4	1112	410.4	8.2	0.5	0.5	118	1.73
69F	770015	7.89	1.3	2.3	0.8	940	335.2	13.2	4.0	0.5	112	0.60
69F	770022	7.80	0.7	0.6	0.9	43	16.0	5.6	0.5	0.5	68	0.39
69F	770023	6.90	1.4	1.0	1.7	40	8.7	5.4	0.5	0.5	62	0.17
69F	770024	4.27	2.0	2.0	3.2	188	23.3	22.1	627.6	4.5	130	0.05
69F	770027	7.74	1.1	0.7	1.0	45	18.6	5.7	5.6	0.5	79	0.05
69F	770028	8.06	1.8	1.3	1.4	90	46.5	11.5	8.7	0.5	72	0.17
69F	770029	7.70	1.6	1.9	3.0	89	20.4	12.6	1.0	0.5	72	0.05
69F	770030	8.23	4.6	6.5	7.6	232	39.8	38.5	0.5	0.5	100	0.05
69F	770031	7.32	4.4	1.7	1.3	38	6.7	4.3	0.5	0.5	65	0.05
69F	770033	7.65	2.7	1.6	2.6	60	12.5	9.0	0.5	0.5	69	0.05
69F	770034	7.44	7.4	3.5	1.8	50	12.1	6.3	1.1	1.8	54	0.20
69F	770036	7.41	3.9	1.9	1.8	48	9.1	5.3	1.1	1.3	56	0.05
69F	770037	7.10	7.3	3.4	2.8	59	10.0	7.7	1.0	0.5	51	0.05
69F	770038	6.92	7.7	5.8	4.2	129	24.4	16.9	41.8	1.0	56	0.24
69F	770044	8.11	5.8	19.7	2.1	161	50.7	20.1	0.5	0.5	108	0.10
69F	770045	7.79	4.1	5.8	2.0	114	28.4	14.9	3.3	0.5	130	0.05
69F	770046	7.94	12.5	103.9	5.6	380	50.0	78.5	0.5	0.5	172	1.20
69F	770047	7.85	2.7	4.6	1.5	48	20.9	12.0	0.5	0.5	141	0.05
69F	770048	8.21	2.5	4.9	1.2	28	13.8	10.3	0.5	0.5	79	0.05
69F	770049	7.23	1.5	1.4	0.5	65	23.1	5.5	0.5	0.5	56	0.05
69F	770050	7.32	1.0	1.1	0.5	40	13.5	4.6	0.5	0.5	54	0.28
69F	770051	7.48	2.3	1.7	0.6	62	24.5	8.0	0.5	0.5	59	0.05
69F	770052	7.74	1.8	1.9	0.6	60	21.5	5.5	0.5	0.5	59	0.05
69F	770053	7.90	40.8	26.9	5.0	164	58.3	29.1	0.5	0.5	100	0.80
69F	770054	8.07	4.4	5.2	1.2	942	275.0	23.4	0.5	0.5	141	0.96
69F	770055	7.82	6.0	13.5	3.2	188	57.8	30.3	0.5	0.5	123	0.60
69F	770056	7.86	6.7	6.3	1.0	1286	502.2	26.8	1.7	0.5	190	1.76
69F	770057	8.10	0.9	1.3	0.7	968	366.9	3.4	0.5	0.5	91	1.00
69F	770058	8.26	4.3	4.0	1.4	636	136.7	19.7	0.5	0.5	210	0.67
69F	770059	7.98	18.0	11.4	3.4	976	225.8	30.4	0.5	0.5	91	0.60
69F	770060	8.08	7.7	4.2	1.6	1210	379.5	35.8	0.5	0.5	118	0.64
69F	770062	8.20	4.0	3.9	1.0	1264	429.8	14.4	0.5	0.5	87	2.50
69F	770064	8.21	1.8	2.4	0.5	1060	338.1	14.0	1.6	0.5	83	1.30
69F	770065	8.04	0.6	0.7	0.3	934	301.8	5.9	0.5	0.5	108	1.06
69F	770068	8.11	0.5	1.4	0.4	1210	435.1	12.5	0.5	0.5	108	2.10
69F	770072	7.77	7.1	21.2	1.9	430	28.2	12.2	1.0	0.5	83	0.10
69F	770073	4.45	2.1	3.3	0.7	72	8.7	6.5	38.9	1.0	100	0.05
69F	770074	8.25	8.1	37.3	2.7	496	56.3	20.8	0.5	0.5	190	0.05
69F	770077	7.65	16.5	29.7	1.1	474	27.4	12.6	0.5	0.5	180	0.05
69F	770079	7.92	4.7	31.7	1.7	802	202.2	14.8	0.5	0.5	118	1.03
69F	770082	7.99	2.0	2.1	0.7	540	85.1	7.0	0.5	0.5	46	2.45
69F	770083	8.00	0.7	1.4	0.3	982	329.0	10.0	0.5	0.5	100	0.78
69F	770086	7.98	1.3	1.3	0.4	1062	375.2	12.2	0.5	1.0	108	1.45
69F	770087	7.69	0.5	0.3	0.5	766	221.8	2.8	0.5	0.5	69	0.60
69F	770088	7.88	1.2	0.8	0.5	1102	397.7	3.0	0.5	0.5	62	1.70
69F	770089	7.98	1.0	1.5	0.4	996	368.6	12.1	0.5	1.0	83	1.80
69F	770090	7.55	1.9	1.2	0.7	1406	520.1	10.3	2.9	1.2	141	1.48
69F	770091	8.06	2.8	2.1	0.6	1438	530.2	14.6	0.5	0.5	150	2.60
69F	770092	7.59	0.5	0.1	0.1	21	9.1	0.5	0.5	0.5	44	0.10
69F	770093	7.82	0.9	0.8	0.2	1276	490.7	5.6	0.5	0.5	100	0.53
69F	770095	8.08	1.6	1.0	0.5	1362	547.2	9.7	4.0	0.5	141	0.92
69F	770097	8.11	1.7	1.3	0.7	1398	532.3	10.0	0.5	0.5	118	1.10
69F	770098	7.84	1.6	1.1	0.7	1128	402.2	9.7	0.5	0.5	96	0.74
69F	770099	8.08	2.1	1.9	0.9	1280	476.4	6.4	1.7	0.5	91	1.80
69F	770102	8.18	1.0	0.8	0.5	520	124.0	5.2	0.5	2.5	79	0.55
DETECTION LIMITS			1.0	0.1	0.1	10	0.1	0.1	1.0	1.0	40	0.10

Table 13.4

Analytical Data: Stream sediment samples (values in ppm except where noted)

a) Melville Island, District of Franklin

NTS	SAMPLE NUMBER	U	Zn	Cu	Pb	Ni	Co	Ag	Mn	%Fe	Ba	Mo	W	ppb Hg
78H	770002	6.5	28	8	4	8	5	0.1	170	0.95	400	1	2	20
78H	770003	1.2	10	2	2	3	3	0.1	90	0.45	275	1	2	20
78H	770004	2.1	82	6	7	16	8	0.1	75	2.45	425	1	2	20
78H	770005	1.5	70	4	6	10	7	0.1	50	2.20	350	1	2	10
78H	770006	2.7	74	8	7	15	8	0.1	60	2.10	400	1	2	20
78H	770007	2.4	92	10	10	17	8	0.1	65	2.70	400	1	2	20
78H	770008	1.4	38	4	4	7	4	0.1	60	1.25	350	1	2	20
78H	770009	1.5	56	6	5	11	6	0.1	65	1.70	400	1	2	20
78H	770010	1.5	26	6	3	8	5	0.1	65	1.00	300	1	2	20
78H	770011	2.4	16	8	6	11	5	0.1	150	1.10	425	1	2	10
78G	770012	1.4	22	8	4	8	5	0.1	185	0.95	300	1	2	10
78H	770013	1.5	20	6	3	6	3	0.1	250	0.80	425	1	2	5
78H	770014	1.0	20	8	4	7	3	0.1	270	0.85	425	1	2	20
78H	770015	1.6	44	10	5	9	5	0.1	295	1.35	425	1	2	10
78H	770016	1.2	24	6	4	6	3	0.1	235	1.00	350	1	2	5
78H	770017	1.3	44	8	4	9	5	0.1	230	1.20	425	1	2	10
78H	770018	1.9	52	14	7	16	8	0.1	465	1.90	525	1	2	10
78H	770019	1.2	28	8	4	9	5	0.1	185	1.05	475	1	2	5
78H	770020	2.2	46	10	6	12	8	0.1	370	1.45	450	1	2	10
79B	770014	4.8	50	18	6	35	14	0.1	175	1.75	550	4	2	10
79B	770015	2.3	34	16	7	30	13	0.1	205	1.55	550	3	2	10
79B	770016	2.1	22	16	4	25	11	0.1	205	1.50	675	1	2	10

b) Ellef Ringnes Island, District Franklin

NTS	SAMPLE NUMBER	U	Zn	Cu	Pb	Ni	Co	Ag	Mn	%Fe	Ba	Mo	W	ppb Hg
69F	770002	2.3	34	16	4	9	8	0.1	190	1.40	700	1	2	40
69F	770003	3.4	70	18	11	18	12	0.1	265	1.60	525	5	2	370
69F	770004	2.5	164	14	15	15	7	0.1	515	1.35	700	4	2	40
69F	770005	3.2	110	44	18	25	15	0.1	475	1.95	850	4	2	860
69F	770006	2.2	52	18	7	14	17	0.1	370	2.05	675	3	2	30
69F	770007	2.5	36	14	5	14	10	0.1	365	1.50	600	2	2	40
69F	770008	2.3	36	18	5	15	13	0.1	315	1.85	950	3	2	40
69F	770009	2.5	80	34	10	19	18	0.1	320	2.25	1125	4	2	80
69F	770010	3.0	80	28	8	14	26	0.1	420	3.10	850	2	2	50
69F	770011	3.0	78	26	15	20	13	0.1	410	1.80	1500	2	2	350
69F	770013	2.3	54	20	9	18	18	0.1	385	2.15	675	2	2	100
69F	770014	2.5	78	30	15	21	16	0.1	330	1.80	700	2	2	1000
69F	770015	3.2	180	36	16	18	11	0.1	630	1.50	600	2	2	50
69F	770016	1.7	20	10	3	3	5	0.1	60	1.10	450	1	2	10
69F	770017	1.7	26	10	5	7	9	0.1	140	1.05	475	1	2	20
69F	770018	1.9	32	12	6	9	10	0.1	165	1.25	600	1	2	30
69F	770019	1.3	28	12	5	8	8	0.1	120	1.00	525	1	2	30
69F	770020	1.5	22	10	4	5	4	0.1	65	0.80	450	1	2	30
69F	770022	1.0	18	6	2	5	6	0.1	90	0.55	450	1	2	10
69F	770023	1.6	26	8	4	7	9	0.1	110	0.80	575	1	2	30
69F	770024	1.9	24	10	4	6	6	0.1	70	0.75	450	1	2	40
69F	770025	2.4	22	10	4	7	5	0.1	75	0.75	500	1	2	40
69F	770026	2.1	36	16	7	11	9	0.1	100	0.95	525	1	2	60
69F	770027	1.3	28	8	2	8	8	0.1	115	0.95	500	1	4	20
69F	770028	1.4	24	8	4	7	7	0.1	80	0.65	475	1	2	20
69F	770029	1.2	20	4	2	5	5	0.1	75	0.50	500	1	2	10
69F	770030	1.9	26	6	4	5	6	0.1	85	0.60	575	1	2	20
69F	770031	2.0	24	8	4	6	8	0.1	140	0.90	625	1	2	20
69F	770032	1.1	18	4	2	5	7	0.1	145	0.70	450	1	2	20
69F	770033	1.6	22	6	4	7	8	0.1	140	0.85	500	1	2	20
69F	770034	1.3	20	6	3	6	7	0.1	125	0.70	475	1	2	20
69F	770035	1.2	22	8	3	7	8	0.1	125	0.80	525	1	2	20
69F	770036	1.8	16	4	2	5	6	0.1	130	0.60	875	1	2	20
69F	770037	2.3	38	16	7	14	11	0.1	200	1.40	675	1	2	50
69F	770038	1.8	36	10	6	8	10	0.1	185	1.05	600	1	2	30

b) Ellef Ringnes Island, District of Franklin

NTS	SAMPLE NUMBER	U	Zn	Cu	Pb	Ni	Co	Ag	Mn	%Fe	Ba	Mo	W	ppb Hg
69F	770039	2.4	28	18	7	12	10	0.1	200	1.30	600	1	2	50
69F	770040	1.2	22	8	3	6	7	0.1	135	1.10	525	1	2	30
69F	770042	2.2	38	12	6	9	8	0.1	110	1.35	675	1	2	30
69F	770043	3.6	74	36	11	16	10	0.1	105	2.85	550	1	2	70
69F	770044	1.7	44	14	6	21	12	0.1	305	1.80	575	1	2	50
69F	770045	1.6	28	6	5	14	8	0.1	165	1.00	475	1	2	20
69F	770046	2.5	44	12	8	18	10	0.1	225	1.95	600	1	2	40
69F	770047	2.5	30	6	5	14	9	0.1	240	1.20	525	1	2	30
69F	770048	2.6	38	6	5	16	11	0.1	420	1.34	575	1	2	30
69F	770049	1.2	28	6	3	12	9	0.1	255	1.05	550	1	2	30
69F	770050	1.5	36	8	5	16	10	0.1	375	1.30	625	1	2	60
69F	770051	1.5	30	6	5	13	9	0.1	310	1.05	600	1	2	40
69F	770052	2.4	3.6	6	5	15	10	0.1	320	1.35	575	1	2	30
69F	770053	1.4	3.8	8	5	11	9	0.1	235	1.25	650	1	2	50
69F	770054	2.1	28	6	5	5	5	0.1	95	1.15	525	1	2	60
69F	770055	3.1	56	14	12	16	7	0.1	265	1.25	1075	2	2	60
69F	770056	3.0	34	10	5	12	6	0.1	195	1.10	600	1	2	40
69F	770057	2.8	38	12	6	13	8	0.1	265	1.35	600	3	2	400
69F	770058	1.5	24	6	3	10	7	0.1	215	0.90	550	1	2	40
69F	770059	2.6	24	6	3	11	7	0.1	160	0.85	650	1	2	50
69F	770060	1.6	26	6	3	12	7	0.1	180	0.80	750	1	2	40
69F	770062	3.4	34	12	6	14	12	0.1	240	1.55	800	2	2	60
69F	770063	4.9	192	24	9	51	37	0.1	315	4.55	975	2	2	90
69F	770064	3.0	44	16	9	19	14	0.1	350	2.00	700	3	2	30
69F	770065	3.1	50	14	12	20	11	0.1	305	1.80	950	4	2	40
69F	770066	4.3	16	16	25	34	8	0.1	105	1.60	950	1	2	5
69F	770067	36.9	148	8	8	510	120	0.1	390	16.20	2500	85	4	150
69F	770068	3.5	34	14	9	19	11	0.1	355	1.45	675	5	2	40
69F	770069	3.0	18	10	5	4	3	0.1	25	1.65	500	1	2	20
69F	770070	2.0	28	12	3	5	6	0.1	70	1.90	600	1	2	20
69F	770071	2.1	34	12	4	9	9	0.1	145	1.75	550	1	2	30
69F	770072	1.6	36	12	4	10	7	0.1	120	1.95	575	1	2	30
69F	770073	8.8	24	10	4	4	4	0.1	50	1.70	625	1	2	20
69F	770074	2.4	60	26	8	16	13	0.1	145	2.85	625	1	2	40
69F	770075	2.9	60	32	7	15	12	0.1	115	3.10	575	1	2	70
69F	770076	1.4	28	12	2	6	6	0.1	75	2.00	525	1	2	20
69F	770077	2.2	38	14	4	9	7	0.1	100	2.25	575	1	2	20
69F	770078	2.6	70	32	9	19	14	0.1	240	3.05	575	1	2	50
69F	770079	2.8	50	18	8	17	13	0.1	300	1.95	775	1	2	40
69F	770082	4.0	40	14	5	17	17	0.1	295	1.95	775	4	2	50
69F	770083	3.2	50	16	10	20	12	0.1	330	1.75	700	5	2	60
69F	770084	3.5	46	16	10	21	13	0.1	375	1.90	675	5	2	30
69F	770085	17.1	156	22	34	51	14	0.1	340	1.65	3450	21	2	120
69F	770086	4.8	36	14	12	17	9	0.1	360	1.25	700	7	2	30
69F	770087	2.7	32	12	8	19	10	0.1	255	1.35	550	5	2	30
69F	770088	3.0	30	14	6	15	10	0.1	260	1.40	500	5	2	30
69F	770089	3.5	36	16	10	18	10	0.1	350	1.25	700	5	2	30
69F	770090	4.2	76	18	25	23	23	0.1	335	1.60	950	7	2	30
69F	770091	2.3	22	12	6	22	15	0.1	270	1.45	750	5	2	30
69F	770092	2.9	62	20	14	21	12	0.1	445	1.85	1225	2	2	90
69F	770093	3.0	52	14	14	20	10	0.1	275	1.30	950	5	2	70
69F	770094	4.5	104	14	22	17	9	0.1	370	1.20	1500	7	2	40
69F	770095	3.4	86	12	20	18	9	0.1	260	1.25	650	5	2	40
69F	770096	4.2	130	14	28	15	9	0.1	310	1.50	775	6	2	40
69F	770097	3.9	48	14	11	21	12	0.1	285	1.65	725	6	2	50
69F	770098	2.8	44	20	7	17	12	0.1	340	1.75	725	4	2	40
69F	770099	5.3	114	30	21	17	9	0.1	315	1.35	725	7	2	230
69F	770100	4.3	72	14	15	15	10	0.1	300	1.45	825	3	2	200
69F	770102	3.6	40	12	5	12	10	0.1	260	1.80	700	1	2	70
69F	770103	2.3	78	14	12	12	7	0.1	220	1.10	875	2	2	250
69F	770104	2.7	46	10	10	11	7	0.1	210	1.10	850	1	2	500

Table 13.5

Analytical data: rock samples from Melville and Ellef Rignes islands

NTS	SAMPLE NUMBER	TYPE	SITE	U	Zn	Cu	Pb	Ni	Co	Ag	Mn	%Fe	Ba	Mo	As
69F	770399	SNDS	20	2.9	10	20	1	2	2	0.2	480	5.9	nd	nd	2
69F	770407	SNDS	07	1.8	10	10	14	77	24	0.2	197	5.2	nd	nd	3
	770411	LMSN	66	20.1	48	11	69	30	2	1.0	364	1.4	nd	nd	16
	770412	LMSN	67	22.5	64	15	31	23	2	0.6	466	0.6	nd	nd	10
	770413	LMSN	67	30.7	29	20	31	23	2	0.6	466	0.9	nd	nd	10
	770414	LMSN	67	5.7	13	8	22	14	2	0.2	466	0.4	nd	nd	2
	770415	LMSN	67	25.7	370	16	48	105	16	0.8	371	2.7	nd	nd	51
	770416	LMSN	67	26.9	294	15	45	82	8	0.2	378	32.6	nd	nd	41
	770417	LMSN	67	24.4	235	18	77	64	8	0.8	385	2.7	nd	nd	44
	770418	LMSN	67	23.9	166	21	56	91	29	0.6	350	1.7	nd	nd	26
	770419	LMSN	68	28.7	80	21	40	30	2	0.4	466	4.3	nd	nd	12
	770421	LMSN	82	10.6	24	27	22	36	6	0.4	262	1.7	nd	nd	6
	770423	LMSN	63	13.7	78	21	31	26	15	0.2	500	1.7	nd	nd	4
	770424	LMSN	67	17.4	82	18	12	54	10	0.2	362	0.8	nd	nd	12
	770425	LMSN	90	29.8	60	18	24	26	6	0.2	392	1.9	nd	nd	13
	770426	LMSN	90	21.0	1710	20	150	60	10	1.6	203	23.5	nd	nd	29
	770427	LMSN	90	32.8	42	13	22	23	2	0.2	288	1.0	nd	nd	10
	770428	LMSN	90	54.2	105	16	31	64	15	0.4	546	1.3	nd	nd	22
	770430	LMSN	94	3.9	38	16	18	17	6	0.2	343	1.1	nd	nd	3
	770440	LMSN	90	40.3	65	11	26	23	6	0.4	533	0.8	nd	nd	9
	770441	LMSN	90	34.3	37	16	26	26	2	0.2	546	0.8	nd	nd	9
69F	770442	LMSN	90	31.0	52	15	31	30	5	0.2	460	1.0	nd	nd	9
69F	770701	DIBS	07	1.6	60	41	2	7	29	nd	1720	11.1	218	1	nd
	770702	DIBS	07	1.3	50	29	2	6	27	nd	1750	11.7	211	2	nd
	770707	DIBS	07	1.6	115	7	6	1	14	nd	1200	8.1	268	1	nd
	770710	DLMT	07	1.5	9	4	3	53	16	nd	229	6.3	61	3	nd
	776403	DIBS	64	1.2	68	40	2	5	19	nd	1700	10.5	473	1	nd
	776404	DIBS	64	1.2	456	28	4	4	24	nd	1780	10.1	194	2	nd
	776601	MGDM	66	1.4	211	2	15	14	3	nd	338	0.6	181	7	nd
	776602	MGDM	66	3.1	9	5	2	4	2	nd	290	0.4	13	6	nd
	776605	DLMT	66	1.8	437	14	13	6	2	nd	166	0.5	191	5	nd
	776607	ANDR	66	0.7	99	2	14	0	0	nd	25	0.0	18	4	nd
	776701	LMSN	67	27.1	237	14	48	87	15	nd	448	2.4	3800	38	nd
	776702	LMSN	67	4.6	42	43	60	45	6	nd	173	1.0	52	13	nd
	776703	LMSN	67	16.3	80	21	24	21	4	nd	522	0.7	748	25	nd
	776704	LMSN	67	5.7	11	3	4	9	2	nd	341	0.4	34	5	nd
	778901	LMSN	89	14.9	64	9	13	23	7	nd	330	1.2	274	9	nd
	778902	LMSN	89	1.4	14	8	2	22	8	nd	203	2.4	87	17	nd
	779001	LMSN	90	33.3	123	25	31	82	14	nd	522	3.2	4110	38	nd
78H	770801	IRFM	08	0.9	170	3	2	51	78	nd	73600	7.8	102	1	nd
79B	771401	DIBS	14	2.4	10	8	2	0	6	nd	592	6.8	109	1	nd
	771404	IRFM	14	1.2	22	10	0	9	8	nd	3930	28.9	250	1	nd
	771701	IRFM	17	0.9	20	9	0	5	4	nd	2300	31.9	832	1	nd
79B	771703	IRFM	17	0.9	19	5	0	2	4	nd	642	19.2	245	2	nd

Values in ppm except where noted.

SNDS = sandstone
DIBS = diabase
n.d. = no datum
LMSN = limestone
DLMT = dolomite
ANDR = anhydrite
MGDM = magnesian dolomite
IRFM = iron formation (ironstone)

For U, the stream sediments yield a similar areal distribution to that found in the water samples. Within the Isachsen Formation, samples 54-63 contain U in the range 1.5 – 4.9 ppm, levels which we view as anomalous. These values correspond well with some subtle water anomalies noted above. Close inspection of the underlying Isachsen sandstone revealed patches of coaly fragments and grey sandstone, some of which were found to be slightly radioactive (McPhar TV-1A). Similar situations prevail in the same rock type on the east side of the Dome (samples 11-14), and to the north (samples 46-47). In the last case, no associated radioactivity was observed. With the one exception (sample 73) where U reaches 8.8 ppm, Hassel sandstone, coaly or not, contributes little U to the stream sediments. This particular sample was also accompanied by an acid water (pH 4.45) which contains about 40 ppb Zn. The sediment contains 24 ppm Zn, average for this area. We have already ascribed the unusual chemistry of this sample site to the presence of oxidizing coal.

Stream sediments collected within the Dumbbells Dome structure commonly carried larger quantities of U in the range 2.3 – 5.3 ppm and exceptionally, 17.1 ppm. The areas of most consistent highs corresponded well with water anomalies described previously; viz., samples 3-10, 64-68, and 83-102. All of these samples lie within drainage basins dominated by Pennsylvanian limestone breccias and masses of gypsum.

Inspection of these rocks for radioactivity revealed moderate levels of activity which ranged from 500 cpm to 23 000 cpm (McPhar TV-1A); the highest levels were estimated at the time to be equivalent to 150 ppm U. Subsequent analysis of hand specimens from these sample sites (Table 13.5) yielded lower values. These are discussed later. Gypsum masses gave very low readings as did nearby diabase dykes and sills. Subsequent analysis of typical samples produced values of 1-3 ppm U (Table 13.5).

The data of Table 13.4b show some anomalous levels for other metals. For example, a little Zn, Cu, and Ni were found in streams draining diabase; Zn, Cu, Pb, Ni, Ba, and Mo were found to be associated with streams draining limestone and gypsum within the Dome, whereas streams draining sandstone are characterized by low levels of all other metals except perhaps Zn.

Discussion

Waters from the Dumbbells Dome area (69F) would be expected to carry U if it is present in underlying bedrock. They contain moderate to high levels of $SO_4^=$ and Cl^- (Table 13.3) as well as some $CO_3^=$ (inferred from pH values). In fact $SO_4^=$ levels found are calculated to be about one half of what would be obtained for saturated calcium sulphate solutions at 0°C, viz., 2400 ppm.

All of these ions are well known to complex uranyl ions strongly, but the overwhelming excess of $SO_4^=$ would likely ensure that bis-sulphato-uranyl ions predominate in solution.

Under these conditions dispersion trains in waters are found to be relatively long and diffuse, probably about 5 km, with U levels diminishing as a result of dilution from barren stream waters rather than by adsorption into bed sediments. In fact, this is to be expected, as in the presence of large amounts of sulphate ion, U will be leached from rocks and sediments and retained in solution rather than be reprecipitated into sediments. The overall effect of these processes is to produce very short dispersion trains in sediments. It is quite likely that other metal ions such as Fe and Zn, would also manifest long residence times in solution in these streams. Some detailed "soil" and stream sampling in the centre of Dumbbells Dome demonstrated just how short were dispersion trains in sediments in comparison with waters. Uraniferous limestones (Table 13.5), shattered by frost action to mounds of felsenmeer near sample site 67, were seen to be further weathered and leached to form highly oxidized iron-rich limy muds on the upper banks of a nearby stream, where U reached 36.9 ppm (Table 13.4b). Approximately 25 m farther downslope and just above the stream highwater line, these limy mud flows were found to carry 17.1 ppm U (sample 85). Zn, Ba, and Mo are also present in anomalous levels as they were at site 67.

However, a true stream sediment taken 25 m downstream contained a mere 4.9 ppm U and a little Mo. Fe, present in the upper bank muds at 16.2 per cent was largely depleted (< 2 per cent) in the lower bank muds. Sulphate content of waters washing these muds and sediments was found to be near 1000 ppm (samples 65, 86).

Outside the Dome, dispersion of metals in waters is very restricted, perhaps to less than 1 km. We regard dilution effects from snow melt and permafrost-derived groundwaters as more important controls than adsorption or precipitation of dissolved metal loads in these streams.

Geochemical Studies – Ellef Ringnes Island

Rocks

Analyses of selected hand specimens from the Dumbbells Dome area (69F) are presented in Table 13.5. Data are listed according to the stream site which receives the drainage from these rocks.

The analyses confirm the presence of low grade uranium mineralization in certain limestone breccias of Dumbbells Dome. Values were found to be one third of those predicted from field radioactivity measurements. We conclude that there is some disequilibrium between U and daughter elements such as Ra. In view of the brecciated nature of the rocks, coupled with the action of frost and related severe surface leaching in the area, a disequilibrium situation is not surprising. The hand specimens collected show evidence of supergene alteration; many have limonitic rinds and fracture fill. Visible pyrite commonly was partly oxidized.

The chemistry of Ra dictates that it be retained preferentially to U by adsorption onto barium sulphate, calcium carbonate, or coprecipitation with secondary calcite. In support of this model, inspection of Table 13.5 reveals a close relationship between U levels measured by neutron activation analysis and Ba content of the rocks. On the other hand U as uranyl ion is mobilized efficiently by carbonate ions and by sulphate ions from gypsum and oxidizing pyrite. We intend to analyze some of these samples for Ra to determine the extent of U leaching. In future field operations it will be necessary to dig some shallow pits to check for increased radioactivity at depth and, if possible, to obtain relatively less weathered samples for analysis.

Table 13.5 also indicates that the diabase dykes carry very little U. The evaporites, particularly those carrying fluorite, do carry small quantities of U.

General Discussion and Recommendations for Further Work

It has been established that low grade U mineralization can be found in significant quantities in certain geological settings in the high arctic.

However, the setting in which U was found ultimately was at first surprising. Upon later consideration, it was soon appreciated that a pyritic (now mainly limonitic) brecciated limestone should provide an excellent chemical and physical trap for stray fluxes of uraniferous brines. If this limestone immediately overlies the Otto Fiord (Penn.) evaporites, then it is certainly in close proximity to a possible source of U and perhaps Zn, Ni, Mo, and Ba. Few signs of uraniferous sandstone were found although the coaly Isachsen sandstone, which are also in close proximity to the evaporites, were found to manifest low radioactivity in places.

This and other similar Mesozoic sandstone should not be disregarded at this stage as possible hosts for U mineralization. The setting remains an excellent one. Further studies should be directed towards other evaporite diapirs and related anticlinal domes. These can be found on Axel Heiberg Island, Ellef Ringnes Island, Amund Ringnes Island, Ellesmere Island, and Melville Island. A gypsum mass or diapir within an impact crater on Devon Island is also an interesting site.

At this point it is relevant to discuss the usefulness of the geochemical techniques used in this study.

It was found that both geological and geochemical studies are severely restricted by the nature of the terrain in the high arctic. Rocks which do outcrop are generally badly frost-shattered and are often rendered to nothing more than fine sand or mud. This is especially true of sandstone and shale, whereas carbonate rocks are considerably more resistant to physical weathering processes. Sedimentary rocks which do survive essentially intact are commonly leached to depths of 10 cm or more and are sometimes iron-stained. Often the weathered rind is impregnated with ice crystals which serve as a cement. Even carbonate rocks have thick weathering rinds and in some situations secondary calcium carbonate can be found reprecipitated on the underside of boulders and cobbles. The effects on trace metal content are obvious from inspection of the stream sediment data presented and the very low levels of surface radioactivity observed on traverse. U is one of the more easily leached elements and simply does not persist at surface in this environment. Nor do its radioactive daughter elements whose presence would permit radiometric detection, except possibly in the carbonate breccias where there is some evidence of disequilibrium between U and Ra.

Consequently, as we have already noted, geochemical and radiochemical anomalies are of low level and very subtle. They can be interpreted correctly only with the help of appropriate geological information.

Dispersion trains in waters and sediments are of limited use in the detection of U and trace elements associated genetically with it. This is primarily a problem of dilution imposed upon initially low levels leached from source rocks. Radiochemical detection of sources of U is further restricted by the generally wet terrain. Except for certain relatively more resistant limy rocks and the diabase sheets within the evaporite diapirs, most of the flat-lying terrain is water-saturated or cut by numerous wet drainage channels. It was observed that precipitation of a few millimetres of rain has the effect of turning the top few centimetres of "soil" into a wet, sticky mass. Streams, which seem to flow partly within bed sands and partly above them, would rise perceptibly. Radiochemical measurements probably would be more useful if small pits and trenches were dug to penetrate surface materials, especially in limestone terrane.

Similar experiences have been noted in parts of the Barn and British Mountains of northern Yukon (Goodfellow, pers. comm.). There, similar suppressed geochemical responses occur in streams draining known U showings, and low radiochemical response in flat-lying sandstone and shale terrane were observed. Goodfellow shares our opinion that careful detailed geochemical and geological studies are mandatory to permit valid interpretation of more regional data which may be obtained.

At the present time, sampling of waters appears to be more immediately useful than stream sediments in both northern Yukon and in Queen Elizabeth Islands. Nevertheless, U data derived from each technique do serve to substantiate anomalies detected by the other. Measurements of other trace metal levels, chosen to fit the appropriate genetic models under test, will augment information gathered from U analyses and improve chances of finding significant anomalous areas and perhaps, mineral occurrences.

More extensive, integrated orientation studies of this type are required to establish optimum sample intervals for U and base metal exploration in the high arctic. It is important to note that changes of terrain will probably require specific and detailed attention in order to achieve these objectives, and that no universal methodology is in sight for the high arctic.

Acknowledgments

We wish to acknowledge that logistical assistance provided for us by Polar Continental Shelf Project and the personal advice of its Director, G.D. Hobson. We are also grateful to D.M. Barnett, formerly of the Terrain Sciences Division, for the benefit of his field expertise in arctic conditions, and to L.D. Jones for his assistance in drafting figures.

References

Stott, D.F.
1967: Geology of Ellef Ringnes Island, District of Franklin; Geological Survey of Canada, Map 4-1968, Paper 68-16.

Tozer, E.T. and Thorsteinsson, R.
1964: Geology, western Queen Elizabeth Islands, District of Franklin; Geological Survey of Canada, Memoir 332.