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The Final Days of the Franklin Expedition: New Skeletal Evidence

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ABSTRACT. In 1992, a previously unrecorded site of Sir John Franklin's last expedition (1845–1848) was discovered on King William Island in the central Canadian Arctic. Artifacts recovered from the site included iron and copper nails, glass, a clay pipe fragment, pieces of fabric and shoe leather, buttons, and a scatter of wood fragments, possibly representing the remains of a lifeboat or sledge. Nearly 400 human bones and bone fragments, representing a minimum of 11 men, were also found at the site. A combination of artifactual and oxygen isotope evidence indicated a European origin for at least two of these individuals. Skeletal pathology included periostitis, osteoarthritis, dental caries, abscesses, antemortem tooth loss, and periodontal disease. Mass spectroscopy and x-ray fluorescence revealed elevated lead levels consistent with previous measurements, further supporting the conclusion that lead poisoning contributed to the demise of the expedition. Cut marks on approximately one-quarter of the remains support 19th-century Inuit accounts of cannibalism among Franklin's crew.

Key words: Franklin Expedition, skeletal remains, oxygen isotope analysis, lead poisoning, cannibalism

RÉSUMÉ. En 1992, on a découvert un site non mentionné auparavant, relié à la dernière expédition de sir John Franklin (1845-1848) dans l'île du Roi-Guillaume, située au centre de l'océan Arctique canadien. Les artefacts récupérés sur ce site comprenaient des clous en fer et en cuivre, du verre, un fragment de pipe en terre, des morceaux de tissu et de cuir de chaussure, des boutons et de multiples fragments de bois éparpillés, qui pourraient venir d'un canot de sauvetage ou d'un traîneau. On a aussi trouvé sur le site un total d'environ 400 fragments osseux ou os complets, représentant au moins 11 hommes. En se basant à la fois sur de la documentation archéologique et sur des analyses des isotopes de l'oxygène, on a pu attribuer une origine européenne à au moins deux de ces individus. Les lésions osseuses comprenaient périostites, ostéo-arthrite, caries dentaires, abcès, perte de dents précédant le décès et parodontolyses. La spectroscopie de masse et la fluorescence X ont révélé de forts taux de plomb correspondant aux mesures précédentes, venant ainsi appuyer la conclusion qui veut que l'empoisonnement par le plomb ait contribué à la fin de l'expédition. Des entailles sur environ un quart des ossements confirment les récits inuit du XIX^e^ siècle sur le cannibalisme pratiqué par l'équipage de Franklin.

Mots clés: expédition Franklin, ossements, analyse des isotopes de l'oxygène, empoisonnement par le plomb, cannibalisme

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INTRODUCTION

The Northwest Passage Expedition of 1845, led by Sir John Franklin of HMS *Erebus* with Captain Francis Rawdon Crozier of HMS *Terror*, was one of the worst disasters in the history of arctic exploration. Not only did all 129 crew members perish, but no substantial records have survived to detail the geographic or scientific data collected by the expedition, or to recount the events which led to the final tragedy. Despite the many expeditions dispatched by the British Admiralty in search of Franklin's crew, the only significant written records found to date have been two notes discovered in cairns in the vicinity of Victory Point and Gore Point (M'Clintock, 1863). Skeletal remains of the lost expedition were occasionally located by early search parties, but were considered to be of secondary value until a recent analysis by Beattie and colleagues revealed evidence of scurvy, lead poisoning, and cannibalism (Beattie, 1983; Beattie and Savelle, 1983; Beattie and Geiger, 1987; Kowal et al., 1989). New skeletal evidence described in this paper corroborates their findings.

HISTORICAL BACKGROUND

Events leading up to the loss of the expedition have been reconstructed from evidence gathered by the many search expeditions to the Canadian Arctic (M'Clintock, 1863; Nourse, 1879; Gilder, 1881; Cyriax, 1939; Stackpole, 1965; Klutschak, 1987). In June 1845, Franklin and his crew set sail from England in search of a Northwest Passage that would lead them to the Far East. After sailing through Lancaster Sound

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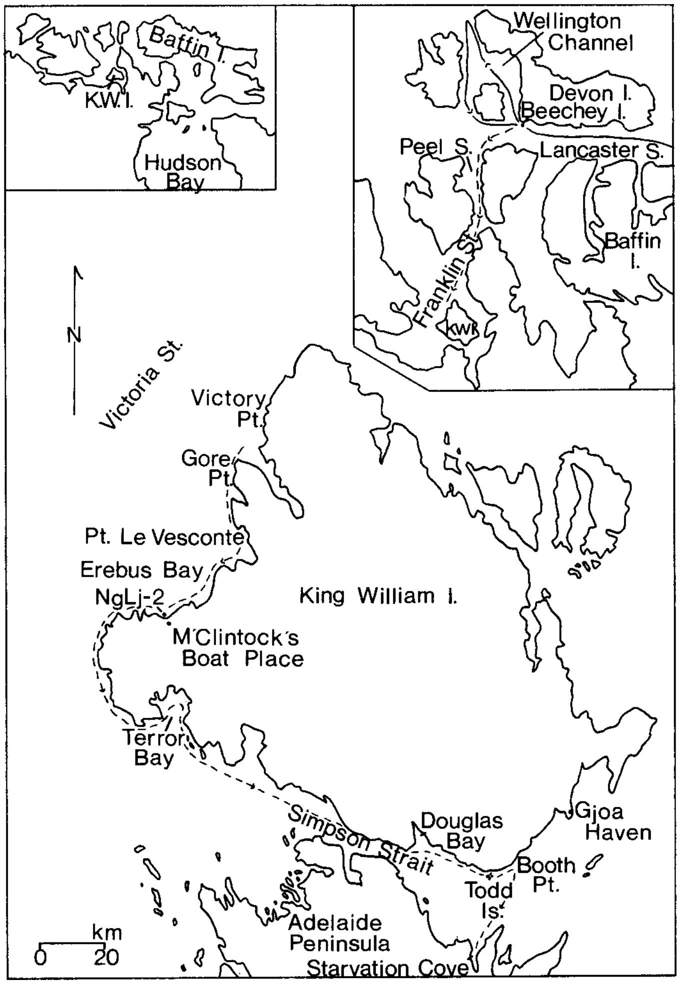

FIG. 1. Map showing the location of NgLj-2, the known route of the expedition in 1845 (right inset), and the presumed route through Peel Sound and along the coast of King William Island.

and Wellington Channel (Fig. 1), the two ships, HMS *Erebus* and HMS *Terror*, spent the first winter at Beechey Island, where three crewmen died and were buried. In September 1846, after presumably sailing through Peel Sound and Franklin Strait, the ships became stranded in ice in Victoria Strait several kilometres off the northwest coast of King William Island, where they remained until April 1848. At that time, the crew, now reduced to 105, deserted the ships and headed south along the western shore of King William Island. Their stated goal was to reach the mouth of the Back River at the southern end of Chantrey Inlet, District of Keewatin, which could eventually lead them to a Hudson's Bay Company post in the interior. Skeletal remains of a number of the crewmen are reported to have been found at Starvation Cove on the Adelaide Peninsula (Gilder, 1881; Klutschak, 1987). Whether or not the remaining survivors travelled beyond this point is unknown (Woodman, 1991:276).

The British Admiralty's search for the missing expedition began in 1848 and continued until 1880. The first skeletal remains of the crew were uncovered in 1859, when a search party under the command of Captain Francis Leopold M'Clintock discovered the remains of a lifeboat containing two skeletons on the shore of Erebus Bay, on the western coast of King William Island (M'Clintock, 1863). In 1869, the American explorer Charles Francis Hall located the skeleton of officer Henry LeVesconte on the southern shore of King William Island (Fairholme Papers, 1873). A subsequent search of the island by Lieutenant Frederick Schwatka in 1879 yielded the skeleton of officer John Irving at Victory Point (Gilder, 1881:124, 285), an additional skeleton near Point LeVesconte (Gilder, 1881:289), and the remains of at least four individuals in Erebus Bay (Gilder, 1881:285; Stackpole, 1965). Other Franklin remains have also been found in Terror Bay (Klutschak, 1987:213), in Douglas Bay (Klutschak, 1987:218), and on the Todd Islands in Simpson Strait (Gibson, 1932). In 1981, Owen Beattie and James Savelle surveyed the northwestern and southern coasts of King William Island and found the skeleton of one crewman near Booth Point (Beattie and Savelle, 1983). In 1982, a continuation of Beattie's survey located the remains of 6 to 14 individuals in Erebus Bay (Beattie, 1983). Also in 1982, Savelle located the remains of two and possibly three crewmen on the Todd Islands (Savelle, 1985).

During the summer of 1992, a survey conducted by Barry Ranford, an amateur historian from southern Ontario, Canada, located another Franklin site (NgLj-2) in Erebus Bay (69°08′30″N, 99°02′17″W) within about a kilometre of what has become known as M'Clintock's Boat Place (Keenleyside and Bertulli, 1994; Ranford, 1994) (Fig. 1). The site is located on a small island just over three hectares in size. Human skeletal remains and artifacts were concentrated in an area of about 300 square metres on the northwestern end of the island, with a thin scattering across the remainder of the island. Over 200 artifacts, most of them fragmentary, were recovered from the site. They included iron and copper nails, copper percussion caps, glass, wire gauze, a clay pipe fragment, pieces of shoe leather and fabric, buttons, a buckle, and a comb (Bertulli, 1995). Characteristics of the buttons and fabric are consistent with a late 1840s date for the site (Schweger, 1994). A 10 m by 15 m surface scatter of wood fragments, most of them oak (Young, 1994), probably represents the remains of a lifeboat or sledge (Bertulli, 1995). Of the 25 faunal bones recovered (Hourston-Wright, 1994), four seal bones may relate to the crew's brief stay at the site (Bertulli, 1995). Nearly 400 human bones and bone fragments were recovered from the site, and are the subject of this paper.

MATERIALS AND METHODS

Most of the human skeletal remains from NgLj-2 were found scattered across the surface, with the densest concentration of bones being situated at the western end of the site. There were no burials, and individual skeletons could not be identified. The absence of any burials is consistent with 19th-century Inuit reports that the crew "fell down and died as they walked along" (M'Clintock, 1863:249). The scattering of elements is likely the result of both human disturbance and animal activity. While some of the smaller bones had rodent tooth marks, the articular surfaces of a number of long bones appeared to have been chewed off by larger mammals.

Morphological observations (based on the presence of eight mandibles) indicated that the remains represented a minimum of eight individuals, while x-ray fluorescence revealed the presence of at least 11 individuals (Keenleyside et al., 1996). The remains included 5 crania, 11 pelvic bones, 12 scapulae, 13 humeri, 10 radii, 7 ulnae, 13 femora, 6 tibiae, and 11 fibulae. Few ribs, vertebrae, or bones of the hands and feet were recovered. While many of the surface remains were bleached and weathered, lichen growth on the bones was minimal and did not hinder examination of the remains for pathology or other features (Keenleyside, 1994). Excavation of eight units measuring one square metre each was required to facilitate the removal of several large bones that were partially visible on the surface (Bertulli, 1995). The elements recovered during this excavation consisted primarily of ribs and phalanges, none of which were articulated. Most of the subsurface elements were in excellent condition, and several of them had dried tissue adhering to their external surfaces.

Morphological (Bass, 1987; Ubelaker, 1989) and metric features (Giles and Elliot, 1962; Gill, 1984; Bass, 1987; Ubelaker, 1989) were used to assess the racial affiliation of the remains. Sex determination was based on standard morphological and metric criteria (Bass, 1987; Ubelaker, 1989), while age estimates were obtained using dental calcification (Moorrees et al., 1963; Anderson et al., 1976), dental eruption (Ubelaker, 1989), epiphyseal union (McKern and Stewart, 1957; Ubelaker, 1989), ectocranial suture closure (Meindl and Lovejoy, 1985), auricular surface morphology (Lovejoy et al., 1985), and sternal rib end morphology (Iscan et al., 1984). Stature estimates were calculated from the maximum lengths of the six major long bones, using the formulae for white males provided by Trotter and Gleser (1958). All remains were examined macroscopically for evidence of pathology. In addition, three mandibles, two radii, and six tibiae were radiographed.

Oxygen isotope analysis of tooth enamel from the molars of two separate individuals was performed at the University of Michigan's Department of Geological Sciences. These data can place limits on the origin of these individuals because: (1) there are known relations between climate variables, such as temperature, the oxygen isotope composition of precipitation, and the oxygen isotope composition of mammalian body water and tooth enamel phosphate at a given locality (e.g., Dansgaard, 1964; Longinelli, 1984; Luz et al., 1984); and (2) the isotopic composition of enamel phosphate is "locked in" during childhood and should remain unchanged even if an individual later migrates to a locality with a radically different climate (e.g., Levinson et al., 1987). Schwarcz et al. (1991) utilized these relations to determine the source of human battlefield remains, while Fricke et al. (1995) used them to investigate the latitudinal temperature differences between human settlements in the North Atlantic region.

Finally, nine cortical bone samples of less than two grams each were analysed for lead content in order to determine if they exhibited high lead levels comparable to those previously reported by Kowal et al. (1989) for Franklin remains from Beechey and King William Islands. This analysis was undertaken in the Geology Department at McMaster University, Canada, using inductively coupled plasma mass spectroscopy. The samples were taken from the anterior midshaft of a right and a left tibia and seven right femora. Following Beattie (1985), only samples of exposed bone were selected in order to minimize lead contamination from the soil. For comparison, lead content was measured in one soil sample, taken from an area of the site approximately 100 m from the main concentration of artifacts and skeletal remains.

RESULTS

Morphological (Bass, 1987; Ubelaker, 1989) and metric features (Giles and Elliot, 1962; Gill, 1984; Bass, 1987; Ubelaker, 1989) indicated the remains to be those of European males. All five crania exhibited features characteristic of European populations, including the presence of a nasal sill, receding zygomatic bones, a long, narrow face, and a narrow nasal aperture (Bass, 1987:83, 87; Ubelaker, 1989:119). Other characteristics included the presence of a metopic suture in one cranium, and the presence of Carabelli's cusps on two maxillary molars. Both of these features are more common in European populations than in other groups (Ubelaker, 1989:119–120).

Age estimates indicated that all of the individuals were under the age of 50 at the time of death. One individual was initially estimated to have been 12 to 15 years of age on the basis of the stage of dental calcification of the third molars (Moorrees et al., 1963; Anderson et al., 1976). This observation led to speculation that this individual may have been one of the four cabin boys on the expedition (Ranford, 1994). However, an examination of the original crew list of HMS *Erebus* and HMS *Terror* (Admiralty Records Series 38, #1962, #672) revealed that the three youngest members on the expedition, all of them cabin boys, were 18 years of age at the time the expedition set sail. A subsequent examination of the baptism records of two of these individuals confirmed that they were, in fact, 18 years of age in 1845 (B. Ranford, pers. comm. 1995). The baptism record of the third individual has yet to be located.

Stature estimates ranged from 162 to 177 cm (Table 1). These estimates correspond closely with the mean heights of recruits to the British Army and Royal Marines born between 1795 and 1830 (Floud et al., 1990). A macroscopic examination of the remains revealed little evidence of pathology. Active periostitis resulting from trauma or infection (Ortner and Pustchar, 1985) was noted on the lateral surface of the midshaft of one right tibia. Five bones exhibited osteoarthritis. Slight osteoarthritic lipping was recorded on the margins of the glenoid fossae of a right and a left scapula. Two ribs exhibited slight pitting and lipping on the articular facet of the tubercle, while a distal phalanx of the foot had moderate lipping on the superior margin of the proximal articular facet.

TABLE 1. Stature estimates.

Element	Maximum Length (cm)	Stature Estimate (cm)
Humerus		
# 177 (left)	31.2	168.27 ± 4.57
# 238 (left)	31.5	169.14 ± 4.57
# 192 (right)	31.3	168.56 ± 4.57
# 319 (right)	33.5	174.92 ± 4.57
# 21 (right)	31.5	169.14 ± 4.57
Ulna		
# 27 (left)	24.6	168.05 ± 4.72
# 23 (left)	26.2	174.06 ± 4.72
# 92 (right)	26.4	174.81 ± 4.72
Radius		
# 40 (left)	23.3	167.73 ± 4.66
# 22 (left)	24.3	171.52 ± 4.66
# 36 (left)	22.9	166.21 ± 4.66
# 239 (right)	25.8	177.20 ± 4.66
Femur		
# 32 (left)	43.8	167.15 ± 3.94
# 53 (right)	42.7	164.59 ± 3.94
Tibia		
# 314 (left)	33.1	162.03 ± 4.00
Fibula		
# 55 (left)	33.4	162.34 ± 3.86
# 244 (left)	38.3	175.08 ± 3.86
# 277 (right)	33.6	162.86 ± 3.86
# 45 (right)	38.4	175.34 ± 3.86

TABLE 2. Bone lead levels.

Bone		Lead Content (parts per million)
Right femur	# 241	49
Right femur	# 243	204
Right femur	# 414	107
Right femur	# 20	160
Right femur	# 53	83
Right femur	# 41	57
Right femur	# 51	103
Right tibia	# 421	83
Left tibia	# 314	82

One atlas vertebra had a cleft neural arch, a congenital malformation of unknown etiology (Mann and Murphy, 1990:50). Dental pathology, recorded by individual and by tooth/tooth socket, included periodontal disease, noted in 38 out of 123 tooth sockets (30.9%) (from six of eight mandibles found); antemortem tooth loss, affecting 36 out of 174 teeth (20.7%) (from four of ten maxillae and three of eight mandibles); dental caries, recorded in 7 out of 70 teeth (10%) (from two of eight mandibles); and dental abscesses, involving 4 out of 180 teeth (2.2%) (from one of ten maxillae and two of eight mandibles). No pathological changes were detected radiographically.

The oxygen isotope composition of the two tooth enamel samples is given in the conventional $\delta^{18}O$ notation (e.g., Rozanski et al., 1993). The $\delta^{18}0$ values are 18.6 and 19.0 per mil, and indicate that the individuals were drinking water

TABLE 3. Skeletal elements with cut marks.

Element	Number recovered	Cut marks Number	(%)	Mean number of cut marks
Frontal	5	0	0	0
Occipital	5	0	0	0
Ethmoid	3	0	0	0
Sphenoid	5	0	0	0
Parietal	10	0	0	0
Temporal	10	0	0	0
Zygomatic	7	0	0	0
Palatine	8	0	0	0
Maxillary	10	0	0	0
Nasal	10	0	0	0
Lacrimal	0	-	-	-
Mandible	8	2	25	3
Manubrium	0	-	-	-
Sternal Body	1	0	0	0
Xiphoid	0	-	-	-
Atlas	3	1	33.3	1
Axis	2	1	50	2
C3-7	6	2	33.3	1.5
T1-12	14	2	14.3	2
L1-5	8	4	50	2.25
Sacrum	4	1	25	1
Coccyx	0	-	-	-
Unidentified vertebral fragments	2	2	100	1
Pelvic bone	11	7	63.6	2.86
Clavicle	6	2	33.3	5.5
Scapula	12	4	33.3	3.5
Humerus	13	4	30.8	2.5
Radius	10	1	10	1
Ulna	7	2	28.6	3
Scaphoid	0	-	-	-
Lunate	0	-	-	-
Triquetral	1	0	0	0
Pisiform	1	0	0	0
Trapezium	0	-	-	-
Trapezoid	0	-	-	-
Capitate	0	-	-	-
Hamate	1	0	0	0
1st metacarpal	4	2	50	3
2nd metacarpal	1	1	100	1
3rd metacarpal	4	2	50	2
4th metacarpal	2	1	50	1
5th metacarpal	3	2	66.7	1
Proximal phalanx	28	12	42.8	2
Middle phalanx	18	3	16.7	2.67
Distal phalanx	15	2	13.3	2
Unidentified phalanges	2	0	0	0
Unidentified metacarpals/metatarsals	6	0	0	0
1st rib	6	0	0	0
2nd rib	4	2	50	1
Ribs 3–12	45	4	8.9	1.75
Rib fragments	28	10	35.7	2
Patella	2	0	0	0
Femur	13	4	30.8	3
Tibia	6	1	16.7	2
Fibula	11	2	18.2	2
Calcaneus	4	2	50	3.5
Talus	5	3	60	1.33
Cuboid	3	0	0	0
Navicular	0	-	-	-
1st cuneiform	1	0	0	0
2nd cuneiform	1	0	0	0
3rd cuneiform	0	-	-	-
1st metatarsal	2	2	100	1.5
2nd metatarsal	0	-	-	-
3rd metatarsal	1	1	100	1
4th metatarsal	2	0	0	0
5th metatarsal	2	0	0	0
Unidentified bone fragments	51	1	2	1

with a δ^{18}O value of approximately -5.6 per mil during their childhood (Longinelli, 1984). Given the reasonable assumption that these remains are those of either Inuit or Franklin's men, this value of -5.6 per mil can be compared with the weighted mean δ^{18}0 values of modern precipitation for several European and North American stations (Rozanski et al., 1993): Valentia Observatory in Ireland (51.93˚N, 10.25˚W), -5.4 per mil; Liège, Belgium (50.70˚N, 5.47˚E), -6.8 per mil; Groennedal, Greenland (61.22˚N, 48.12˚W), -11.9 per mil; Thule, Greenland (76.52˚N, 68.83˚W), -24.1 per mil; and Goose Bay, Canada (53.32˚N, 60.42˚W), -15.0 per mil. Because the inferred value of -5.6 per mil is much closer to that of the European stations than to that of the North American stations, it is safe to conclude that the individuals in question were raised in western Europe rather than the North American Arctic.

Lead levels in the nine bone samples ranged from 49 micrograms per gram of dry bone (parts per million or ppm), to 204 ppm (Mean = 103.1, SD = 49.7) (Table 2). In contrast, the soil sample yielded a value of only 2 ppm.

The most noteworthy aspect of the analysis was the discovery of cut marks on 92 bones, or approximately one-quarter of the total number of bones (Table 3). Most of the affected elements were recovered from the western end of the site, where the densest concentration of bones and artifacts was found. The cut marks, which ranged in length from 2 to 27 mm, were easily distinguished from animal tooth marks by their sharper borders, narrower width, and wider spacing (Ubelaker, 1989:105). In contrast to cuts made by stone tools, the observed cuts, examined under a scanning electron microscope, exhibited features characteristic of cuts made by metal blades, namely straight edges (Fig. 2), a V-shaped cross-section, and a high depth-to-width ratio (Walker and Long, 1977; Walker, 1990).

Cut marks were noted on most types of elements, including the clavicles (Fig. 3), scapulae, humeri, radii, pelvic bones (Fig. 4), ribs, vertebrae (Fig. 5), femora, tibiae, metacarpals, tarsals, metatarsals, and proximal, middle, and distal phalanges. Of those elements with cut marks, the pelvic bones were the most frequently affected element (64%), with a minimum of four individuals being involved. The five crania, two patellae, and three carpal bones recovered from the site showed no cut marks. While 45% of the affected bones had single cuts, 55% had multiple cuts, which tended to occur in clusters. Approximately one-quarter of the affected elements had cuts in the vicinity of articular surfaces (Fig. 6).

In addition to the cut marks, three long bones—two radii and a tibia—had been fractured, resulting in exposure of the medullary cavity. While experiments have demonstrated that long bones fractured when green (i.e., fresh) are characterized by smooth edges with small step fractures (Bonnichsen and Will, 1980), postmortem weathering of the fractured edges of the three bones in question made it difficult to determine whether the breakage had occurred shortly after death, while the soft tissues were still intact, or much later in time. While two of the crania exhibited some postmortem damage to their inferior surface, the evidence was not suggestive of intentional breakage. None of the bones found at the site showed any evidence of burning.

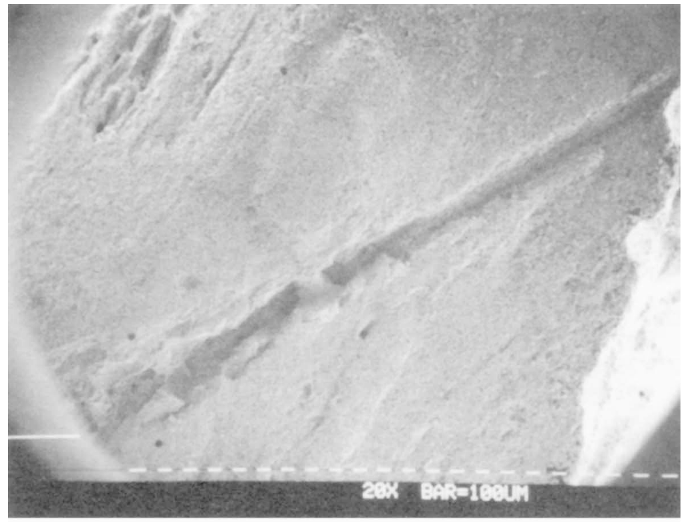

FIG. 2. Cut mark seen under scanning electron microscope.

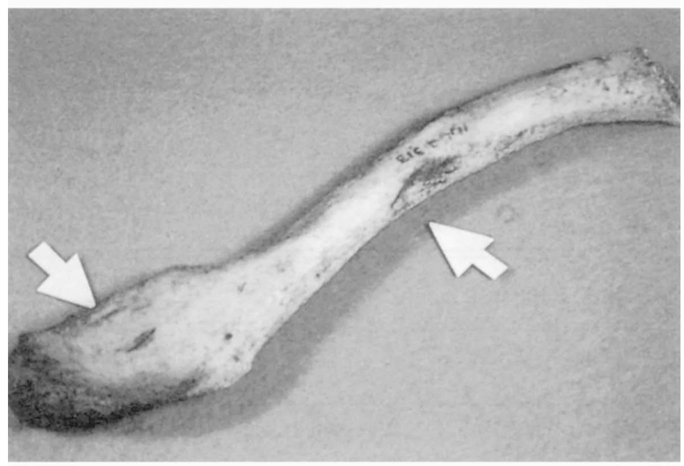

FIG. 3. Cut marks on a left clavicle.

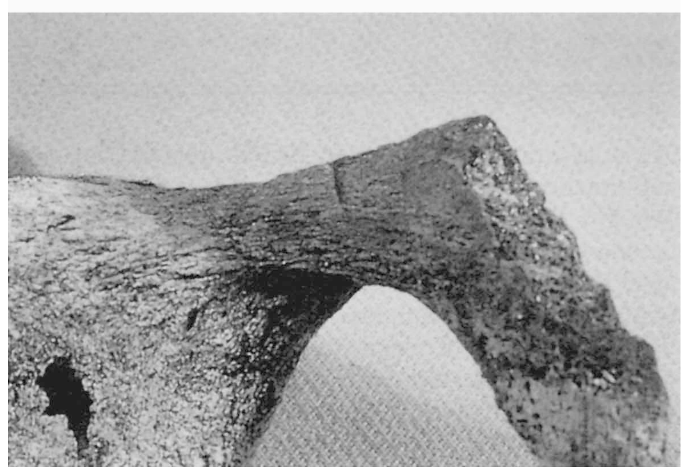

FIG. 4. Cut marks on a left pelvic bone.

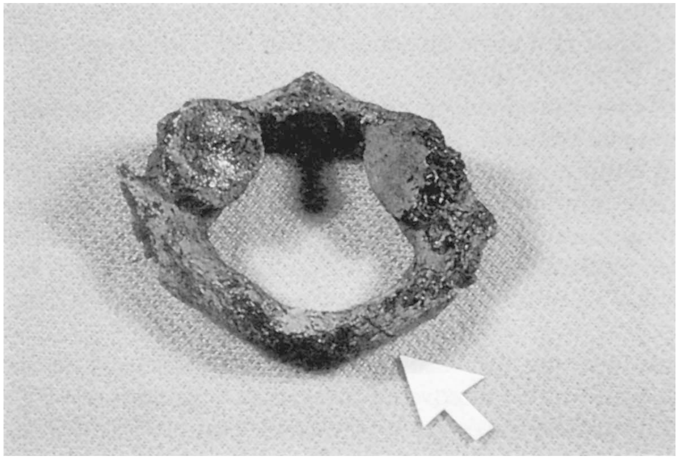

FIG. 5. Cut mark on an atlas vertebra.

DISCUSSION

Lead Poisoning

Previous analyses of Franklin remains have indicated that members of the expedition suffered from lead poisoning (Beattie and Geiger, 1987; Kowal et al., 1989, 1991). Lead levels equal to or greater than those found in modern individuals exposed to high lead environments and in individuals who are clinically lead poisoned were recorded in bone and hair samples recovered by Beattie from Franklin sites on King William and Beechey Islands (Kowal et al., 1991). This finding prompted Beattie and colleagues to conclude that lead poisoning was a significant factor in the loss of the expedition (Beattie and Geiger, 1987; Kowal et al., 1989, 1991). Lead isotope ratio analysis revealed the source of this lead to be improperly soldered tin cans supplied to the expedition (Kowal et al., 1991), although this interpretation has recently been challenged (Farrer, 1993).

The results obtained in the present study are consistent with previous analyses of lead levels in Franklin remains, and indicate that the crew members from NgLj-2 had high body lead burdens. Values of 49 to 204 ppm measured in bone samples from the site closely match the range of 87 to 223 ppm measured in 27 bone samples collected from Franklin sites on King William Island in 1982 (Kowal et al., 1989). The means of both sets of samples are significantly higher than the mean lead level reported by Kowal et al. (1989) for five modern cadaver samples from Vancouver, British Columbia ($t = 4.17, p < 0.05$). They are also significantly higher than the mean level reported by Kowal et al. (1989) for 19th-century Inuit bone from King William Island ($t = 5.90, p < 0.05$), and 19th-century caribou bone (mean = 2 ppm), indicating that lead contamination in the local arctic environment did not contribute significantly to the high bone lead levels measured in the crewmen.

The discovery of high lead levels in bone samples from NgLj-2 has recently been corroborated by a second study of bone lead content using x-ray fluorescence (Keenleyside et al., 1996). This study, which measured lead levels in a sample of 52 bones (mandibles, crania, vertebrae, pelvic bones, humeri, radii, ulnae, femora, tibiae, fibulae) from the same site, yielded values equivalent to 600 to 1500 micrograms of lead per decilitre of blood. When these levels are averaged out over the three years of the expedition, they are 3 to 10 times higher than the recommended upper limit of 40 to 60 ppm for occupational exposure (Nearing, 1987). Clinical symptoms of lead poisoning are related to blood lead content (Lalich and Aufderheide, 1991). While there is considerable variation between individuals, symptoms of blood lead levels over 80 ppm generally include vomiting, constipation, colic, and weakness in the extensor muscles. At levels of over 200 ppm, symptoms include colic, extensor muscle paralysis, and coma (Handler et al., 1986, cited in Lalich and Aufderheide 1991:262). Therefore blood lead levels on the order of those estimated above would have had serious physiological and neurological effects on these individuals.

Cannibalism

Rumors of cannibalism have been linked to several arctic expeditions, including Franklin's first overland expedition of 1819–22 (Franklin, 1823) and the Greely expedition of 1881–84 (Berton, 1988). Accounts of cannibalism have also been documented in the Arctic in very recent times (Keenleyside, 1995), and there is good archaeological evidence indicating that cannibalism occurred in prehistoric times as well (Melbye and Fairgrieve, 1994).

Reports of cannibalism occurring during Franklin's third expedition first surfaced in 1854, when Dr. John Rae, who was conducting a survey of the central Arctic coastline, encountered at Pelly Bay an Inuk named In-nook-poo-zhe-jook, who told him that six years earlier, a group of 35 to 40 Europeans had been seen pulling a sledge and boat down the coast of King William Island and that their bodies had later been found near Starvation Cove (Neatby, 1970:245, 354). More shocking to Rae were Inuit reports that the bodies had been cannibalized (Neatby, 1970:245; Klutschak, 1987:xxiv). In his report to the British Admiralty, published in the *Times* of London on October 23, 1854, Rae wrote: "From the mutilated state of many of the corpses and the contents of the kettles, it is evident that our wretched countrymen had been driven to the last resource—cannibalism—as a means of prolonging existence" (Rae, 1854).

Despite public opposition to Rae's account, Inuit stories of cannibalism among Franklin's crewmen continued to surface. In 1869, during a trek across the southern shore of King William Island in search of the missing expedition, the American explorer Charles Francis Hall encountered Inuit who gave him eyewitness accounts of cannibalism among Franklin's men. In one account, the Inuk In-nook-poo-zhe-jook spoke of seeing some "long boots" that "came up high as the knees and that in some was cooked human flesh—that is human flesh that had been boiled" (Hall Collection, Fieldnotes, Book #26, 1869). In another account, an Inuk named Eveeshuk described "one man's body when found by the Innuits flesh

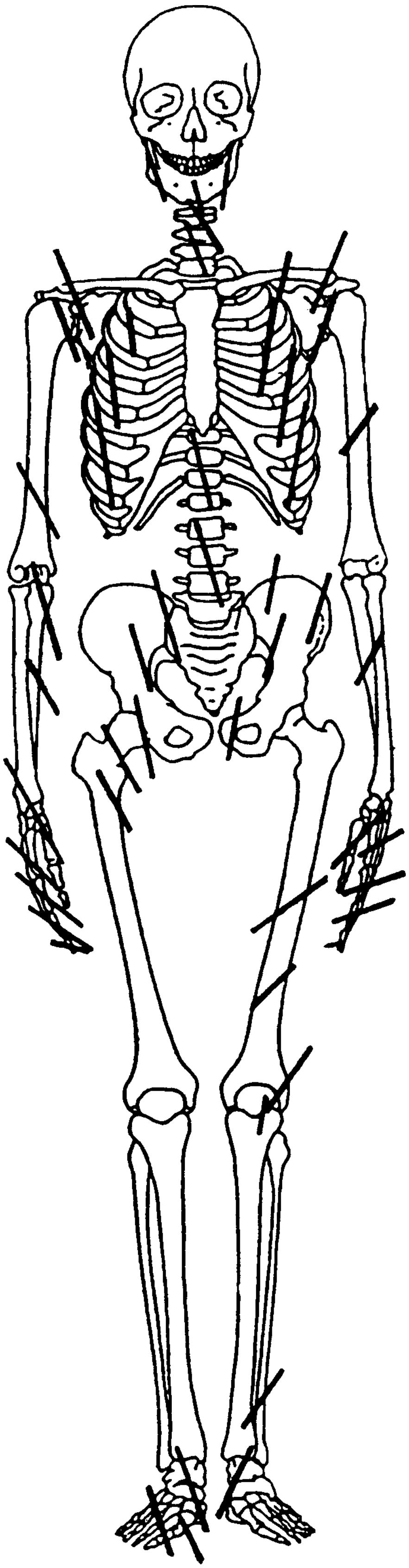

FIG. 6. Location of cut marks on all skeletal remains combined (lines do not indicate direction of cut marks).

all on and not mutilated except the hands sawed off at the wrists—the rest a great many had their flesh cut off as if some one or other had cut it off to eat" (Hall Collection, Fieldnotes, Book #34, 1869).

Similar accounts of cannibalism among members of the Franklin expedition were gathered by Lieutenant Frederick Schwatka, who conducted a search for the missing crew on King William Island in 1879. According to one report, an Inuk named Ogzeuckjeuwock "saw bones from legs and arms that appeared to have been sawed off … The appearance of the bones led the Inuits to the opinion that the white men had been eating each other … His reason for thinking that they had been eating each other was because the bones were cut with a knife or saw" (Gilder, 1881:106–107).

Such accounts were the only evidence that cannibalism occurred on the expedition until 1981, when Beattie discovered cut marks on the shaft of a right femur recovered from a Franklin site on the southeastern coast of King William Island (Beattie, 1983). In addition to the cut marks, Beattie found that the skull of the same individual showed evidence of having been intentionally broken. Other signs that cannibalism might have occurred included the fact that most of the bones recovered from the site were limb bones, possibly retained as a "portable food supply" (Beattie and Geiger, 1987:62), and the fact that many of the bones were found clustered outside a tent circle, as if intentionally deposited there (Beattie and Savelle, 1983).

Turner and Turner (1995) identify five criteria that must be met before an interpretation of cannibalism can be made from human skeletal remains: cut marks, perimortem breakage, anvil or hammerstone abrasions, burning, and missing vertebrae. While these criteria were developed specifically for skeletal remains from the American Southwest, where cannibalism is believed to have occurred under circumstances other than famine (Turner and Turner, 1995), one and possibly two of these criteria, cut marks and perimortem breakage, are present in the skeletal remains from NgLj-2 and are consistent with the 19th-century Inuit accounts of cannibalism. Particularly revealing is the distribution of cut marks on the remains. Approximately one-quarter of the cut marks are located in close proximity to articular surfaces (Fig. 6), a pattern consistent with intentional disarticulation (Ubelaker, 1989:105). Affected areas include the articular and spinous processes of the vertebrae, the glenoid fossa and coracoid process of the scapulae, the distal articular surface of the radius, the margin of the greater sciatic notch of the pelvic bones, and the condyles of the femora and tibiae (Table 4).

The location of the cut marks is also consistent with defleshing, or removal of muscle tissue, specifically, the flexor digitorum profundus of the ulna, the deltoid and triceps muscles of the humerus, the vastus medialis and vastus intermedius of the femur, and the tibialis anterior and posterior of the tibia. Evidence for decapitation is suggestive, but not conclusive. The cut mark on the posterior arch of the atlas vertebra (Fig. 5) suggests severing of the posterior atlanto-occipital ligament, while cut marks on one axis vertebra are consistent with severing of the ligamentum flavium (Melbye and Fairgrieve, 1994). The significance of cut marks on the metacarpals, metatarsals, and phalanges is unknown.

The fracturing of long bones to facilitate marrow extraction has been used as an indicator of cannibalism (Villa et al., 1986; White, 1992). As stated earlier, the time of occurrence of the fractures recorded in the three long bones from NgLj-2 cannot be determined; however, the fractures are consistent with Inuit reports that many of the bones at the site had been "broken up for the marrow in them" (Hall Collection, Book "B," 1871:137).

CONCLUSIONS

To date, the skeletal remains of less than two thirds of the 105 crewmen who abandoned ship in the spring of 1848 have been located. Many of the remains

TABLE 4. Location of cut marks by region.

Element	Region of Cut Marks	Affected regions/Observed regions
Mandible		
	medial surface of right ascending ramus	1/8
	posterior margin of right ascending ramus	1/8
	lingual surface of anterior body	1/8
	medial surface of left body	1/8
	inferior margin of left body	2/8
Atlas		
	inferior posterior arch	1/3
Axis		
	right pedicle	1/2
	left superior articular surface	1/2
Third to seventh cervical vertebrae		
	anterior body	1/6
	right pedicle	1/6
	left superior articular process	1/6
Thoracic vertebrae		
	superior margin of body	1/14
	inferior margin of body	1/14
	right lateral surface of body	1/14
Lumbar vertebrae		
	superior surface of body	2/8
	superior margin of body	1/8
	inferior margin of body	1/8
	spinous process	1/8
Vertebral fragments		
	pedicle	1/1
	left superior articular process	1/1
Sacrum		
	left superior articular process	1/3
	left ala	1/3
Pelvic bone		
	ischial tuberosity	1/8
	acetabulum	1/9
	iliac fossa	2/9
	iliac tuberosity	1/9
	iliac crest	2/9
	margin of greater sciatic notch	2/10
	superior ramus of pubis	1/1
Clavicle		
	midshaft	1/6
	acromial end	2/6
Scapula		
	coracoid process	1/2
	glenoid fossa	2/9
	medial border	1/5
	lateral border	1/9
	spine	2/10
Humerus		
	head	1/7
	midshaft	3/13
Radius		
	distal shaft	1/9
Ulna		
	proximal shaft	1/7
	midshaft	2/7
1st metacarpal		
	proximal shaft	1/4
	midshaft	2/4
2nd metacarpal		
	distal shaft	1/1
3rd metacarpal		
	proximal shaft	1/4
	middle shaft	1/4
	distal shaft	1/4
4th metacarpal		
	distal end	1/2
5th metacarpal		
	proximal shaft	1/3
	distal shaft	1/2
Proximal phalanx		
	proximal shaft	3/27
	midshaft	1/28
	distal shaft	5/28
	proximal articular surface	1/27
	distal articular surface	3/27
Middle phalanx		
	proximal shaft	1/18
	midshaft	1/18
	proximal articular surface	2/18
Distal phalanx		
	shaft	2/15
2nd rib		
	shaft	2/4
Third through twelfth ribs		
	shaft	2/30
	neck	1/45
Rib fragments		
	shaft	13/28
Femur		
	lesser trochanter	1/13
	neck	1/13
	midshaft	2/13
	lateral condyle	1/3
	distal shaft	1/13
Tibia		
	lateral condyle	1/1
	proximal shaft	1/6
Fibula		
	midshaft	1/11
	distal shaft	1/5
Calcaneus		
	lateral surface	1/4
	tuberosity	1/4
Talus		
	trochlear surface	2/5
	medial malleolar surface	1/5
	anterior articular surface	1/5
1st metatarsal		
	proximal shaft	1/2
	distal shaft	1/1
	proximal articular surface	1/2
3rd metatarsal		
	midshaft	1/1

uncovered by the early search expeditions were gathered up and buried in cairns. Unfortunately, most of these cairns have been dismantled over time and their contents lost (Beattie in Klutschak, 1987:222–223). Of the 105 crewmen, only three have been identified (Gilder, 1881:125, 285; Neatby, 1970: 265; Klutschak, 1987:xviii; Woodman, 1991:117, 160), and the identity of one of these individuals has recently been questioned (Woodman, 1991:153). While the skeletal remains recovered from NgLj-2 give no clues at the present time to their identity, they do offer some insight into the physical condition of the crewmen during their final days. Elevated lead levels in the remains are consistent with previous measurements (Beattie and Geiger, 1987; Kowal et al., 1989) and support the conclusions of Beattie and colleagues (Beattie and Geiger, 1987; Kowal et al., 1989, 1991) that lead poisoning had greatly debilitated the men by this point. The presence of cut marks on approximately one-quarter of the remains supports 19th-century Inuit accounts of cannibalism on the expedition.

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