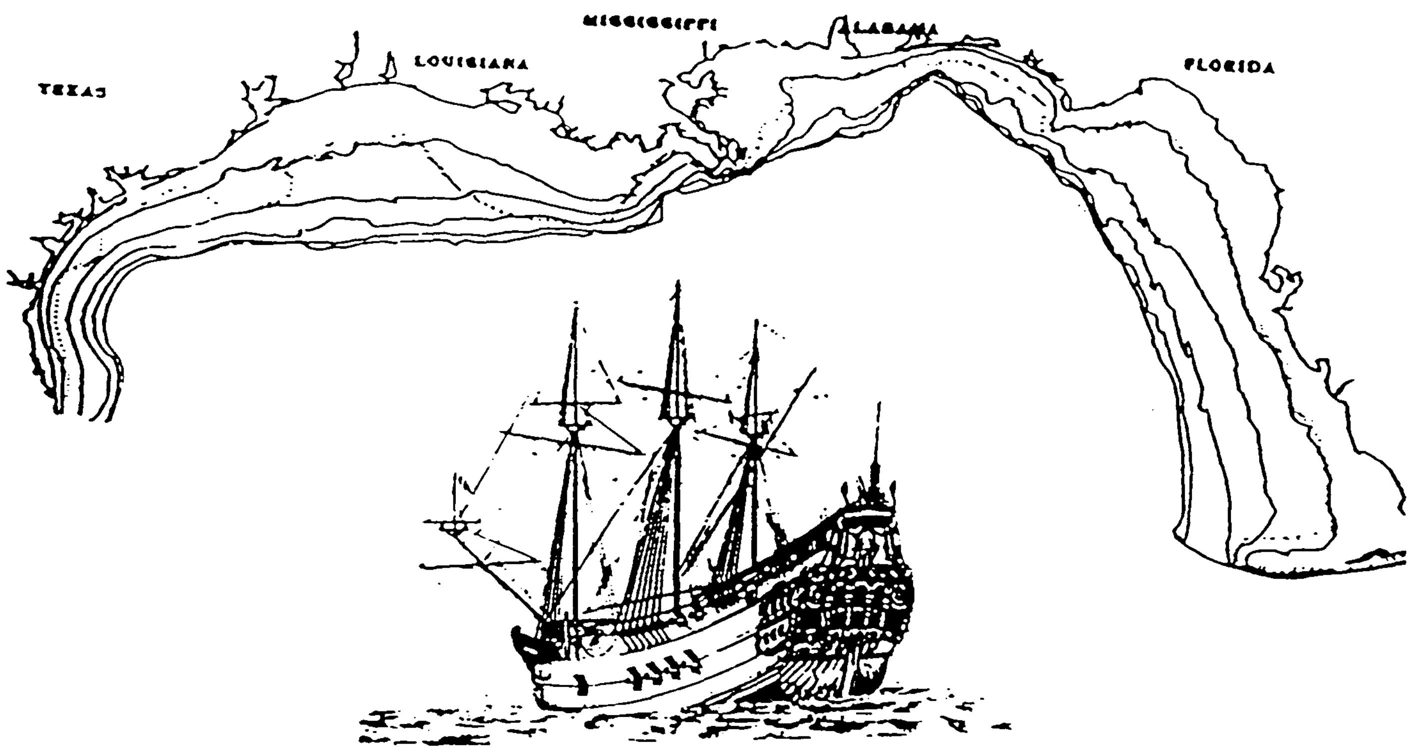
OCS Study
MMS 89-0092

An Eighteenth-Century Ballast Pile Site, Chandeleur Islands, Louisiana

An Instrumental and Archaeological Study



MMS
U.S. Department of the Interior
Minerals Management Service
Gulf of Mexico OCS Region

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An Eighteenth-Century Ballast Pile Site, Chandeleur Islands, Louisiana

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ABSTRACT

The Chandeleurs form an arcuate sweep of low-lying islands and spits for over 60 km northeastward of the Mississippi River delta. They lie within U.S. Territorial Waters and form the eastern barrier shoreline of Louisiana. In 1988, an archaeological site was located 1.5 km east of the northern islands that comprise this island chain in 7 m of water. This site was composed of a ballast pile, pottery sherds, a lead patch, a probable lead pump tube, and six iron cannon. The site lay within an area of historic shipping activity during the Colonial period, being on principal routes to New Orleans via the Mississippi River at East Pass. Instrumental surveys and trial excavations were conducted in May and July of 1989. This research was sponsored by the Minerals Management Service, U.S. Department of the Interior under permit from the State of Louisiana. The instrumental survey resulted in a magnetometric and acoustic characterization of the site as a well-defined assemblage of materials with one or two satellite areas of interest nearby (100 m). Mapping and excavation further refined this picture. Two cannon were raised along with other materials associated with an 18th century vessel. Analysis of the various data suggests the site was either the location of a possible grounding of a vessel with subsequent lightening by intentional discard of unnecessary ballast and ordnance or a shipwreck site with no hull or cargo remains whose genesis is not well understood at present. The site provided valuable new data on historic shipwrecks in the northern Gulf of Mexico as regards their instrumental characterization and evaluation of the preservation of these vessels on the OCS.

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ACKNOWLEDGEMENTS

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1.0 EXECUTIVE SUMMARY

During the course of a larger study of shipwreck patterning, the opportunity to investigate a suspected historic shipwreck off the Chandeleur Islands presented itself. That study evaluated a three-fold (1500 to 4500) increase in the number of known shipwrecks for the Northern Gulf of Mexico for non-random patterning and determined the Chandeleurs to be an area of high probability for shipwrecks due to the incidence of shoals, shipping routes and hurricanes. Located in an area of 18th century French maritime activity, the site represented a chance to test hypotheses concerning probabilities for locating historic shipwrecks, their quality of preservation and instrumental signatures.

The Chandeleur Islands study was a first opportunity to obtain scientifically acquired data on a possible historic shipwreck in the east-central MMS planning areas. Present MMS Task I (shipwreck potential) and Task II (instrumental characterization) models (Garrison et al. 1989) were based primarily on western planning area data. The Chandeleur Islands site provides an effective, easy test of the Task I and II hypotheses concerning instrumental characterization and shipwreck potential for this area. Methods used were:

- A magnetic and side-scan sonar survey of the site.
- Groundtruthing and reconnaissance level survey of the site.
- Mapping and recovery of a small suite of identifiable and chronologically datable material from the site.

The Chandeleur Islands study characterized a ballast pile as to magnetic and side-scan sonar features. It allowed an opportunity to provide systematically collected groundtruth data which correlated with the instrumental data, e.g., magnetic and side-scan sonar signatures of cannon, ballast, etc.

Data from a reconnaissance-level study of the Chandeleur Islands site was a direct test of assumptions used to reevaluate Cultural Resource Management Zone 1 (CRMZ1), e.g., expectation as to the age of the site, type of vessel, and preservation potential in this area. Data to evaluate the predictive value of the models is based on the shipwreck data developed by the Task I study.

The archaeological remains of a rock ballast pile resulting from the grounding or wrecking of a late 18th century vessel of unknown nationality was characterized by the remote sensing survey. Relocation, resurveying and trial excavation of the site produced data that suggested a possible historic wreck site. The archaeological assemblage of the cannon, ballast and other artifacts are all proper attributes of a shipwreck. However, the lack of hull construction features and a dearth of artifacts suggests an alternate interpretation - a stranding with archaeological deposits formed from ballast and old cannon cast overboard during efforts to free the ship, or a wreck with no preservation of hull remains. The site was mapped using an EG&G Model 260 image correcting side-scan sonar with an EG&G Model 272-TD dual frequency tow fish, an EG&G Geometrics G-866 proton magnetometer and a Del Norte Technology Model 542 microwave ranging and positioning system. The site is located off the Chandeleur Islands, Louisiana, approximately 40 km south of Biloxi, Mississippi. The rock ballast pile has six cast iron cannon of which at least three are of Swedish manufacture. The magnetic signature produced by this site was not consistent with the expected signature from six iron cannon, reinforcing the need not to rely on any one remote sensing technique but to combine computer analysis of magnetic and side-scan sonar survey data with groundtruth studies of promising anomalies. Analysis of the cannon and ceramic artifacts associated with the site place the date of the site at no earlier than 1771. Two recovered cannon are currently undergoing conservation treatment at Texas A&M University. Both are struck or inscribed with three fleur-de-lis insignia.

The overall significance of the Chandeleur Islands site lies in the development of important data to better characterize historic sites. The groundtruthing and reconnaissance level archaeological study, including mapping and recovery of datable artifacts or structural materials, was an important test of the results of the previous MMS-sponsored studies.
These results included:

- expectations of vessel type and age for the east-central MMS planning area. The area was designated a high probability area for historic shipwrecks of the colonial period and this was confirmed.

- preservation potential for a historic shipwreck within this area. The site produced no preserved wood of any moment. The metal of the two recovered cannon, upon conservation, have proven to be heavily infiltrated by chlorides thus reducing the ferrous nature of the metal. Within the limits of the present data the preservation potential is judged to be low.

2.0 INTRODUCTION

Early in 1988 the discovery of a possible shipwreck site near the Chandeleur Islands presented an important opportunity to develop further data on instrumental signatures of such sites and to evaluate expectations as to factors affecting the type and preservation of these materials. The Chandeleur Islands Site represents the first chance to develop such data for the northern Gulf of Mexico, east of the Mississippi River. Evaluation of this site provided significant data for the instrumental characterization of historic archaeological sites, as well as the overall distribution and preservation of such sites.

The site location was confirmed in May, 1989. It is located near the northern end of the Chandeleur Islands and was suspected to be a Spanish or French vessel from about 1750 (Figure 2-1). Six cannon were found atop a pile of ballast stones. The significance of this finding related well to a recently completed MMS study (Garrison et al. 1989) which considered: (1) The location and distribution of shipwrecks, spatially and temporally; (2) Factors affecting this distribution; and (3) Factors affecting the preservation of these shipwrecks. Data developed in a study of a location like the Chandeleur Islands Ballast Pile site can be used to evaluate the predictive value of models presented by Garrison et al. (1989).

Also, in the second part of the earlier study by Garrison et al. (1989), the instrumental characterization of modern marine debris and historic shipwrecks was evaluated by magnetic and acoustical means. The Chandeleur Islands Site provided an opportunity to develop further magnetic and acoustical data on suspected historic shipwrecks using a methodology of instrumental survey and groundtruthing to correlate these data to physical attributes of the site, e.g., ballast, cannon, fasteners, etc. By comparing these results with the 1989 study and other works (Arnold 1980, 1982; Clausen and Arnold 1975; Gearhart 1988; Irion 1985; Saltus 1986; Weymouth 1986) it was expected that further confidence could be gained in the instrumental characterization of these sites and their differentiation from modern marine debris. The examination of the variety and preservation of various shipwreck materials was an important facet of the study.

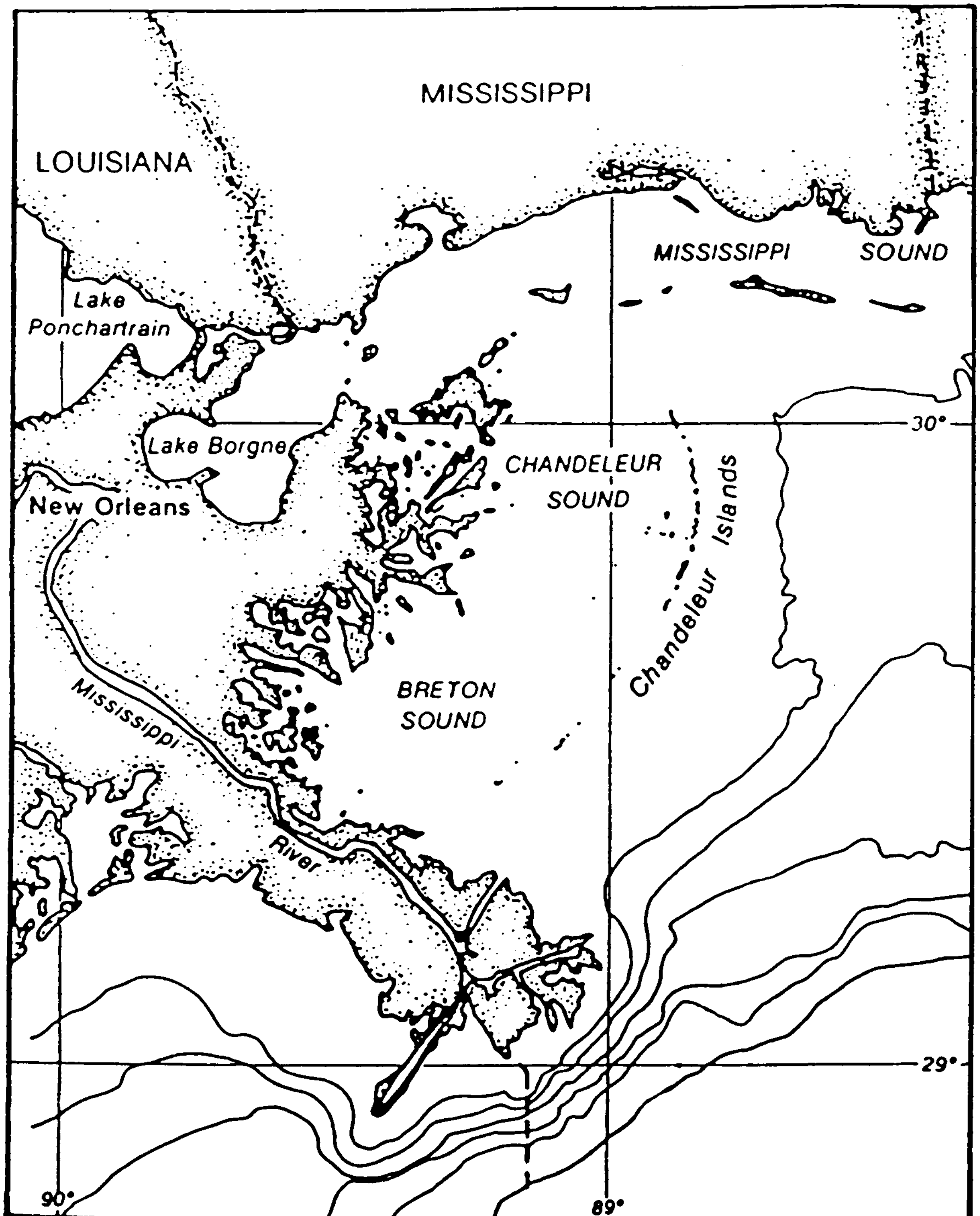


Figure 2-1. Chandeleur Islands Site Map.

3.0 OBJECTIVES AND METHODS

3.1 Objectives

Garrison et al. (1989) developed an overall model of shipwreck patterns in the northern Gulf of Mexico. In that study, the authors synthesized a variety of written and digital databases [CEI 1977; Chaunu and Chaunu 1955; Automated Wreck and Obstruction Information Service (AWOIS); Hydrographic Office (HO); National Ocean Survey; Texas Antiquities Committee (TAC); the Bureau of Archaeological Research (BAR, State of Florida)] to derive chronological patterns of shipwrecks over 20 and 50 year periods. They evaluated these patterns against a small suite of factors which included: (a) historic shipping routes; (b) port locations; (c) hazards; (d) currents and winds; and (e) historic hurricane paths. It is beyond the scope of this present report to review those results which are treated exhaustively by Garrison et al. (1989) and summarized by Garrison (1989). The importance of those studies to this one lies in the refinement of a picture for potential 18th century shipwrecks in the east-central area of the northern Gulf (Louisiana-Mississippi-Alabama-West Florida) and in particular the Chandeleur Islands.

Based on those studies it became apparent that during the 18th century French, Spanish and British maritime activity had resulted in numerous early losses in the vicinity of the Mississippi Delta and the Chandeleur Islands. When information about a possible historic shipwreck off the northern Chandeleurs became available it was compared to the data base and shipwreck patterns then under development. The confirmation of the site location by divers of the study team correlated well with expectations for maritime losses in that area. After consultation with the study sponsor, Minerals Management Service (U.S. Department of the Interior), and the State of Louisiana, a modest study program was developed whose objectives were to:

- instrumentally survey the site using high resolution geophysical techniques (magnetometer, side-scan sonar)
- conduct a groundtruthing archaeological study to develop data to correlate with instrumental signatures determined above.

3.2 Methods

To arrive at the objectives stated above, the study proceeded along lines previously developed in the 1989 MMS study (Garrison et al 1989). Briefly, these were:

- survey the site location using a methodology as prescribed in NTL 75-3 (Notice to Lessees, 1982, Revised; and subsequent letters to lessees) requirements for geo-hazards and cultural resources survey;
- resurvey the site using a closer interval lanespacing (50 m or less) than specified under NTL 75-3 (revised);
- use magnetometer and side-scan sonar instrumentation coupled with precise survey positioning (≤5 m); and
- conduct an archaeological groundtruthing study using mapping, excavation, recording, and analytical techniques of site features and data.

The instrumental survey results were processed using graphic software programs that produce profile, contour, and isometric views of the magnetic data. These data were merged with contemporaneous side-scan sonar data by use of geographic position. The geographic frame of reference was established by satellite positional fixes of shore reference stations (Figure 3-1) used by the short-range microwave vessel positioning system.

After review of the instrumental data in its various analog and digitally-processed formats, an underwater archaeological examination of the site was begun. A mapping baseline was erected as well as lanes for photographic recording. A series of units were excavated and recorded using standard techniques. Both still and video recording was utilized. Artifacts recovered were recorded and conserved according to their specific needs (see Sections 7 and 9).

Figure 3-1. Shore reference station for short range positioning system. Also shown is the TRANSIT satellite receiver used to establish geographic position.

4.0 ENVIRONMENTAL SETTING

To the 18th century observer, the Louisiana coast was skirted by a "barrier beach, little banks of sand forming sort of a double coast" (Chaville 1903). The Chandeleurs lie seaward of the marshy mainland and shallow Chandeleur Sound that overlie the St. Bernard Delta (Figure 4-1). This delta was active roughly 2,800 to 1600 years ago (Kolb and Van Lopik 1966)(Figure 4-2). The islands, along with the southernmost Breton Island, form a convex arc from the Mississippi Delta to the Mississippi Sound.

Chandeleur Facies sand is a fine-grained, well-sorted, quartz (Ludwick 1964). The beaches are composed of this and shell. Otvos (1982; 1985) suggests the Chandeleurs resulted from the redistribution of the St. Bernard sub-delta sands wherein, after abandonment of the delta lobe, bay-fill sedimentation stops, subsidence and coastal retreat start. The Chandeleurs are the oldest of the deltaic barrier islands and are regressing less rapidly than the others, ca. 1.5 m per year (Morgan and Larimore 1957).

The Chandeleurs are under constant wave attack with the entire arc moving westward. On the Chandeleur Sound or leeward side of the islands are dwarf mangrove swamps that get buried as the islands retreat (Russell 1936; Morgan and Treadwell 1955). Dunes up to 7 m rise behind the beaches in many places (Figure 4-3). Grasses and succulents comprise much of the dune vegetation while along brackish water ponds on the backside of the dunes other species such as cattail, *Phragmites* and black mangrove flourish. The area from the brackish pond to the Sound consists of a *Spartina alterniflora* dominated salt marsh. Rabbits, foxes, raccoon, alligators and snakes are abundant together with various other small mammals and birds which make up the complex barrier island ecosystem. Aside from the mangroves, there are no trees. This ecology differs from the other barriers north of the Chandeleurs such as Cat, Ship, Horn and Dauphin Islands which contain large stands of white pine.

The immediate environment of the site is composed of the Chandeleur Sand Facies extending seaward (≥10 km) and landward ~1.6

km). It is a flat topography between 6 and 7 m below sea level. Sand movement is constant due to tidal and storm-generated currents. During the recovery of the cannon (July 1989) tidal current velocities easily exceeded two knots (1.0 m/sec) during the ebb. The ballast rock were encrusted with barnacles, coral (*Astrangia*) and sponge (*Haloclina*) growth. Reef species of nekton and other fauna (eel, octopus, crab, spadefish, cobia, shark, mangrove snapper, etc.) were observed.

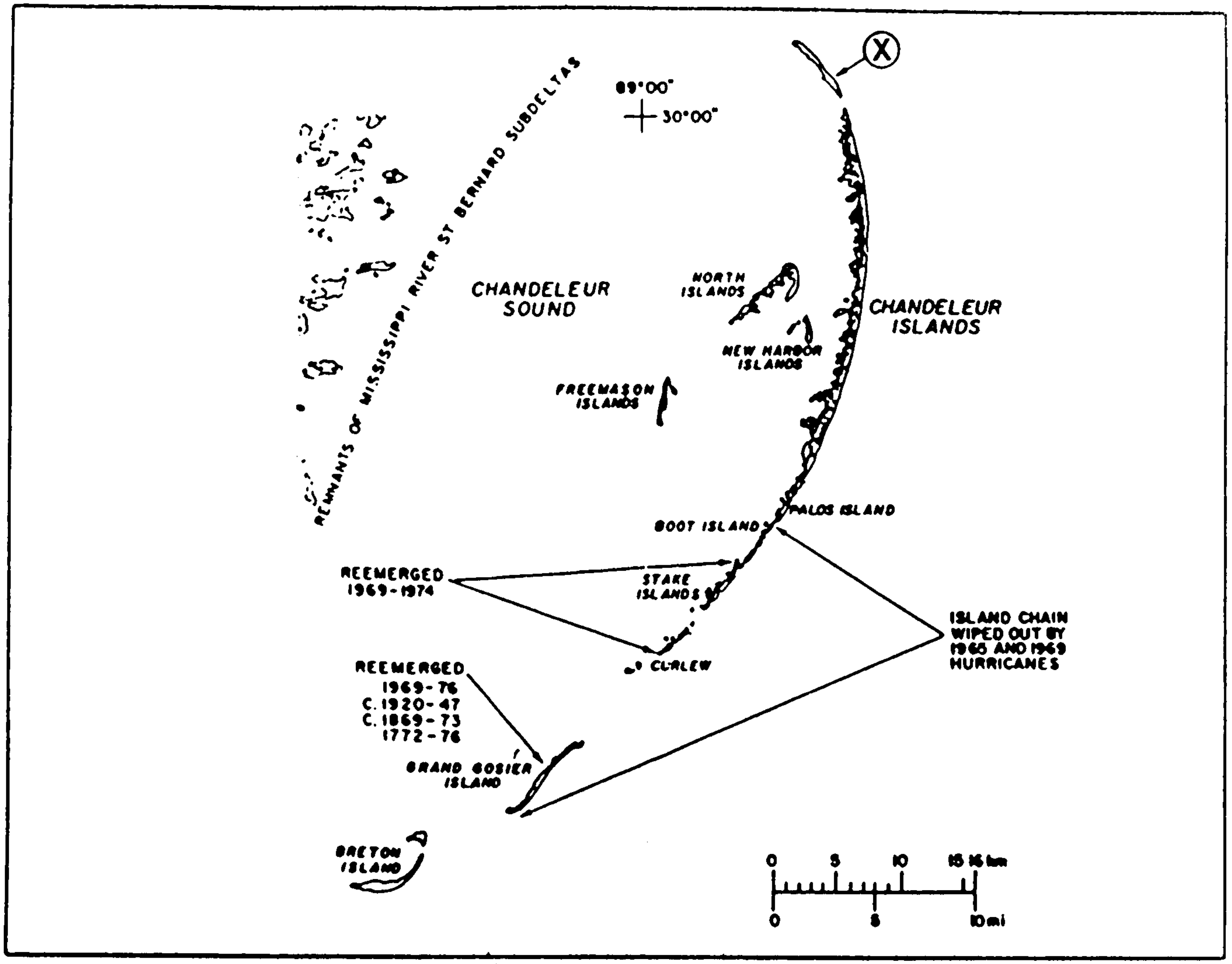


Figure 4-1. Chandeleur barrier island chain, Louisiana. Position of the archaeological site is indicated by "X." Map is modified from Otvos (1982).

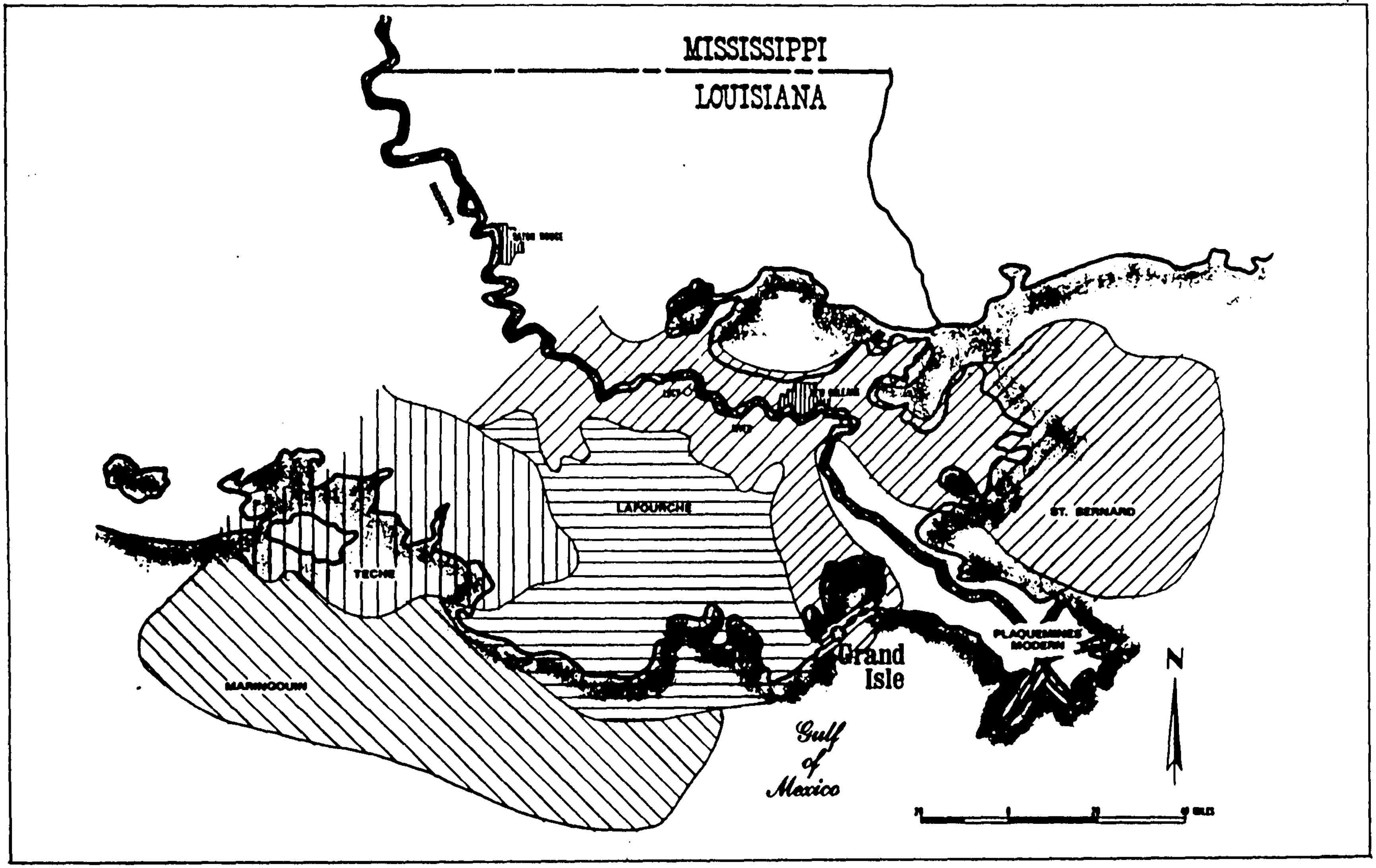


Figure 4-2. Mississippi River Sub-Deltaic Areas.

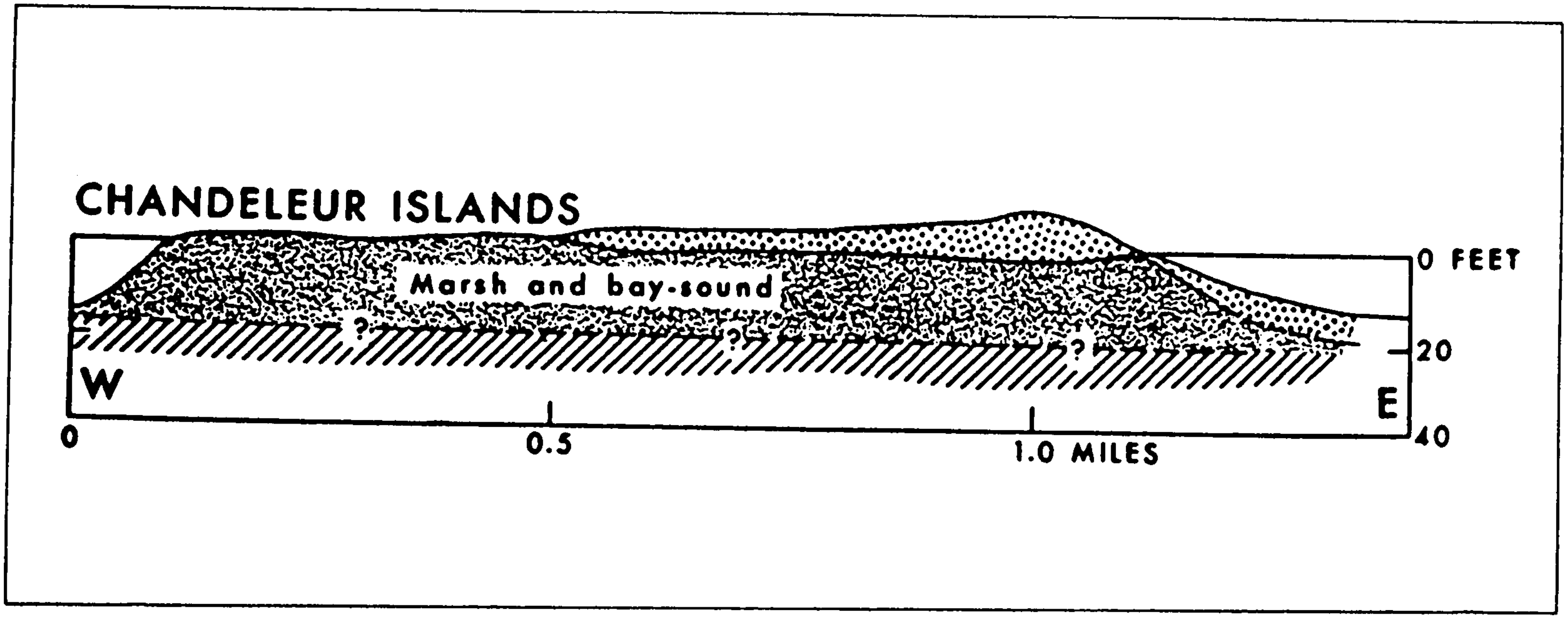


Figure 4-3. Sediment facies of delta barrier islands. Barrier sands are undifferentiated. The diagrams of Chandeleur Islands is after Treadwell (1955).

5.0 HISTORICAL SETTING

5.1 La Louisiane - 1699-1763

Colonization of the northern Gulf coast resulted in the wreck of western european vessels such as the one that produced the Chandeleur Islands site. This expansion, in the Gulf area, was led by Spain and then France. The motivation was based in the geopolitics of that period which in turn involved imperialism, religious conflict and commerce.

The european economics of the 16th to 18th centuries were closely linked to the reduction of costs and hazards of long distance voyages (Davis 1973; Mendlessohn 1976). The broad-scale political-economic trend termed the "long 15th century" (Cippola 1976; de Vries 1976; Wallerstein 1974; 1980) played a key role in triggering the colonial expansion of the European polities who in turn reaped the rewards in terms of increasing trade volumes, prices and accumulation of capital (McGovern 1985). Spain and Portugal led in this expansion particularly into the New World.

By the mid-16th century, Spain's investment in its New World venture was repaid by net capital flows from America to Spain. The Spanish imports tripled the total supply of money in Europe over the level seen at the beginning of the century (Walton and Shepherd 1979). Hamilton (1934) postulates a "price revolution" wherein prices greatly outstripped wages (costs) to the advantage of capitalists or entrepreneurs. Economic growth and commercial expansion were fed by the large profits generated by the differential in prices and wage. Spanish treasure flooded Europe with specie by which imports and military expeditions were paid (soldier's pay and military procurements) (Walton and Shepherd 1979).

The following period, the "long 17th century," was one of economic stagnation, recession or crisis (Wallerstein 1974; 1980; de Vries 1976) during which Holland, England and France challenged the Iberian hegemony in the Caribbean. In the Gulf, this struggle was not resolved until after the end of the Seven Years War (1763). As inflation followed, problems caused by the increased money supply occurred in Europe leading to the stagnation of the 17th century. This did not slow European colonization of the New World. Land and wealth beckoned to the overcrowded citizens of Western Europe (McGovern 1985). This impacted the northern Gulf of Mexico at the end of this initial period with the coming of the French (1685)(ibid; Weddle 1987). The difference between the Spanish and the French lay in the emphasis by France of the export of raw materials from America in exchange for European manufactures. Commodities won out over treasure in the long term. This key change in the overall system and its ramifications for historic shipwrecks has been examined in a recent publication (Garrison et al. 1989; Garrison 1989).

With the successful establishment of the French at Biloxi in 1699, port development east of the Mississippi delta began in earnest. Spurred by this successful French challenge, the Spanish fortified and developed Pensacola (Figure 5-1a) into a port (Weddle 1985). Over the following century, the French settlements, particularly Mobile (Figure 5-1b), developed cooperative ties with Pensacola, often to the chagrin of Havana or Seville authorities. With closure of Spanish ports to the English in 1713, France followed suit, refusing English and Dutch ships from entering Louisiana ports (Surrey 1916). This reflected the larger struggle of France and England for North America. At the level of the infant colony of Louisiana it made trade with the mother country and the Spanish a necessity.

Before 1717, vessel tonnage averaged 30-60 tons for French ships with sizes increasing under the Company of Indies control to anywhere from 110 to 500 tons. After 1736, vessels increased in size from 250 to 700 tons (Surrey 1916). Spanish and English vessels calling on Louisiana were typically small, about 50 to 60 tons.

Biloxi (1699) was quickly supplanted by Dauphin Island (1701) and Mobile (1702) as principal ports of Louisiana. New Orleans was founded in 1712 and rapidly became Mobile's chief competitor. By 1738, New Orleans enjoyed a brisk trade with the Spanish merchant vessels from Cuba, St. Augustine, Pensacola, St. Bernard Bay, St. Joseph Bay, Porto Bello, Darien, and Cartagena (Surrey 1916). By 1754, Mobile had overtaken New Orleans with a trade valued at 50,000 paistres a year (A.N.C. Ser. C. XXXIV). Ships

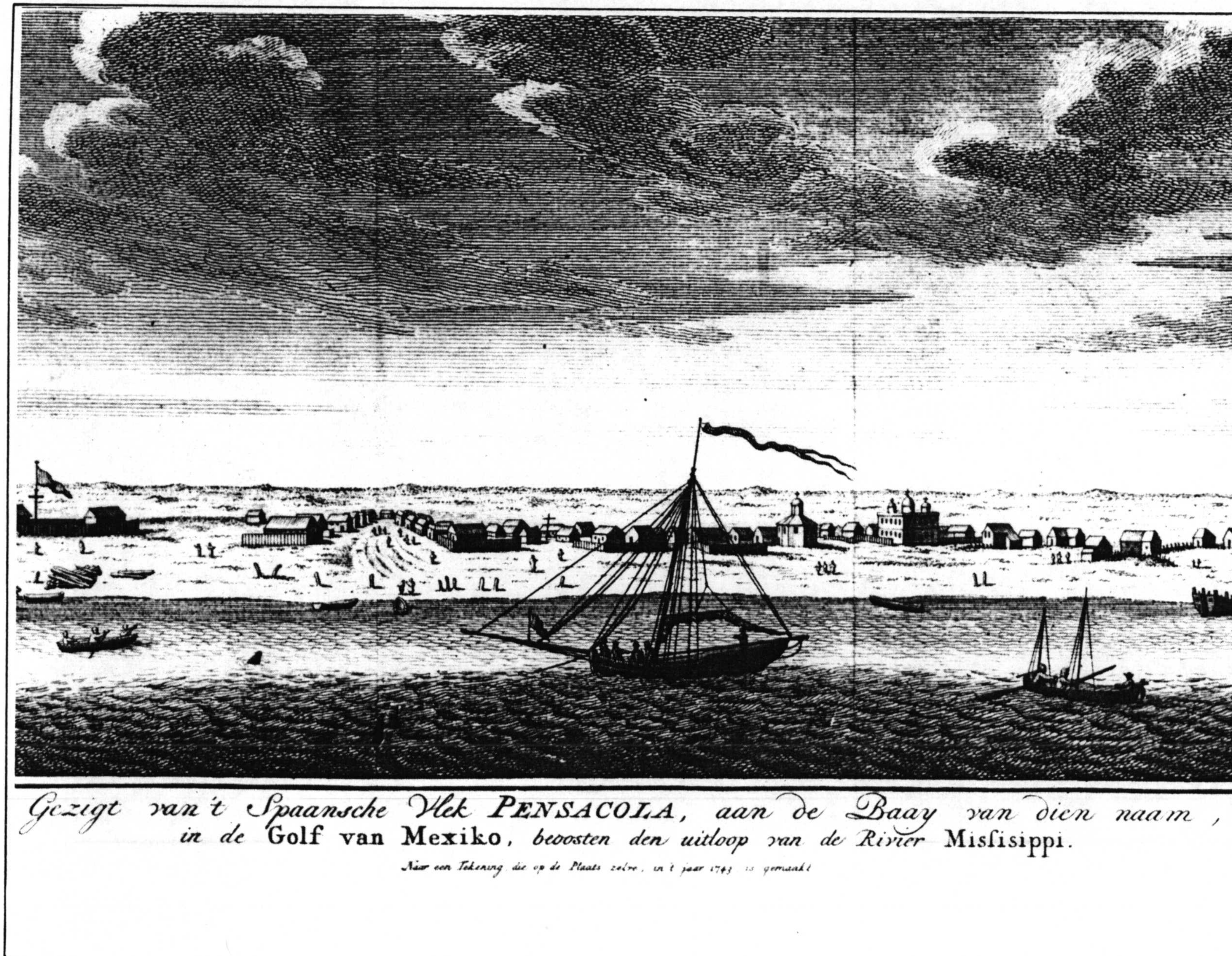


Figure 5-1 (a) Pensacola, ca. 1743.

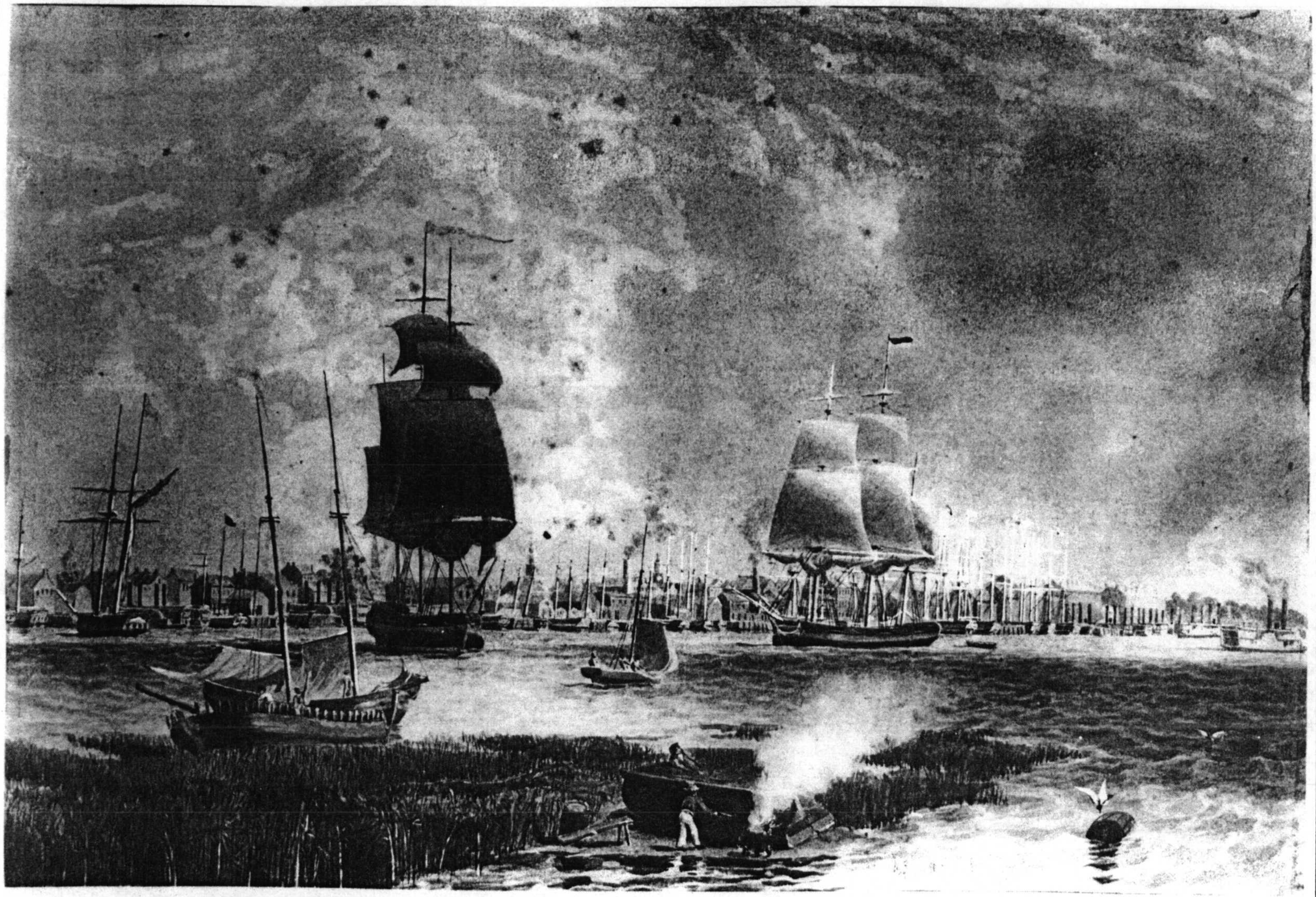


Figure 5-1 (b) Mobile, ca. 1841.

ostensibly calling on Pensacola made for Mobile (ibid) but the Spanish port enjoyed trade with Mobile and New Orleans.

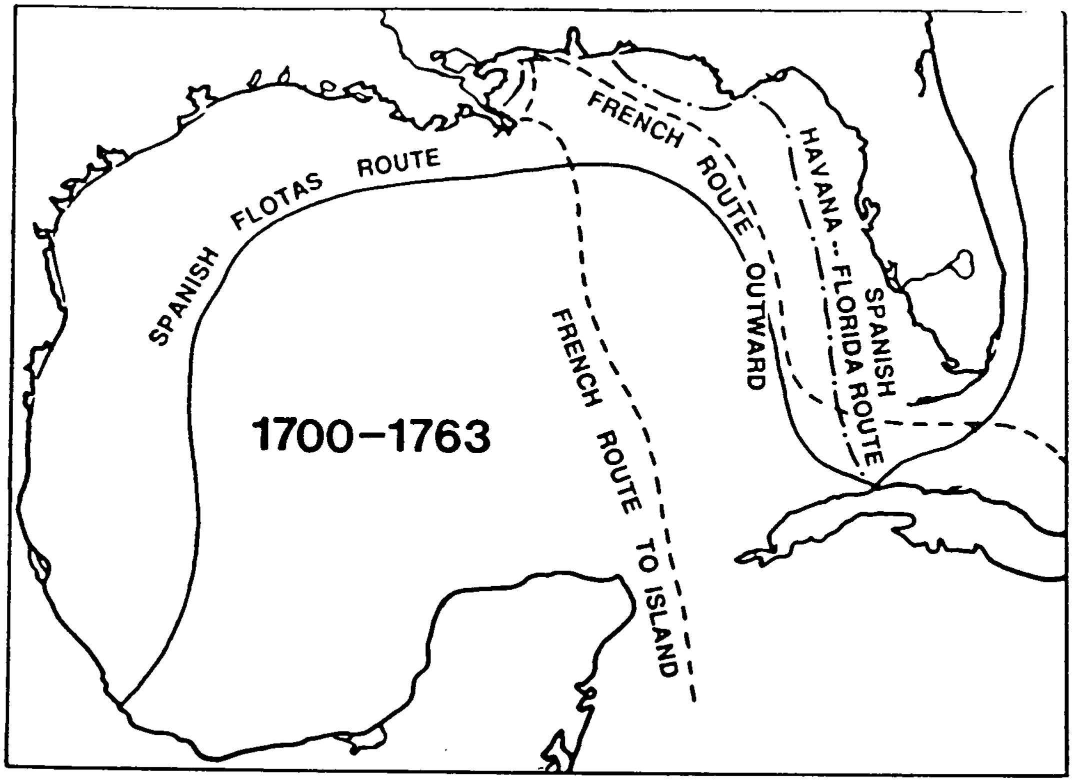
During the Chickasaw War (1744-1748), the Spanish trade with the French colony boomed. An interesting footnote to this situation was that the colony relied on paper money. This was due in large part to the fear of losing coin in a shipwreck. Trade with the Spanish brought specie into the province in the form of silver pistoles (Caldwell 1974).

Imports brought to Louisiana from French ports included European consumer goods such as cloth, lace, wine, and brandy (Surrey 1916). Spanish traders brought Brazil wood, cacao, cochineal, tortoise shell, leather, indigo, sasparilla, snuff and vanilla (Le Page du Pratz 1774). The colony exported lumber, rice, pitch, tar, peltry, and tobacco (Surrey 1916).

French vessels sailed from their home ports directly to Louisiana before 1711. This journey required 46 days to Cape Francais and another 46 to New Orleans (A.N.C. Ser. C. XIV). However, three to four months were typical (A.B.A.E., AM, i). From 1717 to 1731, vessels voyaged via the French West Indies, both outbound and return (A.N., C., Ser. B. XXXIX; Ser. C V). In 1748-1749 vessels were ordered by the crown to sail directly to Louisiana without stop due to war with Britain (Surrey 1916).

Routes from the Indies through the Yucatan Channel are those given by Romans (1775) and routes from the Louisiana coast or Pensacola are given by Hutchins (1784). These are little different from Spanish routes with the exception that they stand to the coast rather than make the great turn to the Straits of Florida (Figure 5-2). Entrance to the Mississippi River was typically at East Pass with its early settlement of Balise (Figure 5-3).

France lost her North American empire with her defeat in the Seven Years War. "La Louisiane," French since the reign of Louis XIV was given up to the Spanish along with New Orleans (Ronciere 1932). The British gave Spain control of Mobile and westward while creating the province of West Florida with its administration from Pensacola. In 1781, Galvez ended Britain's brief hegemony of the northern Gulf with the taking of Pensacola (Rowland 1911; Chipley 1877). Spain was encouraged in this by



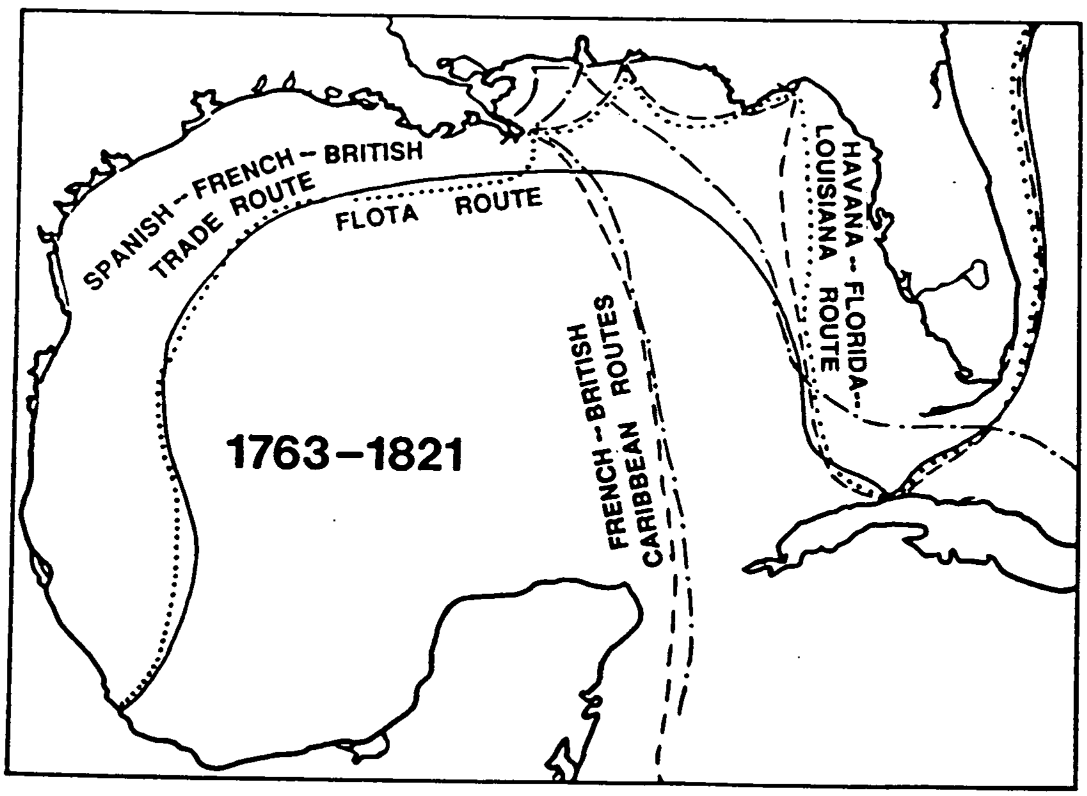


Figure 5-2. Shipping routes: (a) 1700-1763 and (b) 1763-1821.

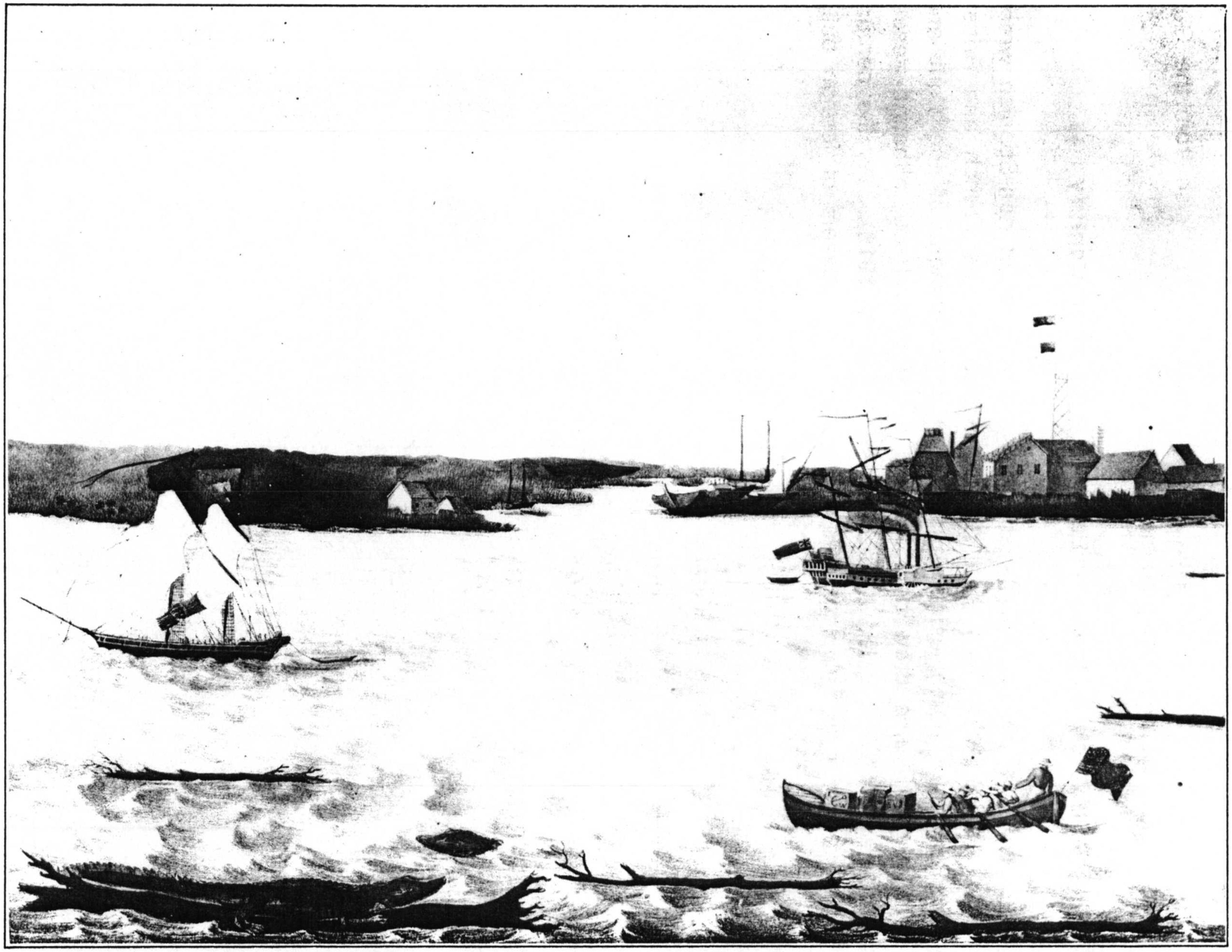


Figure 5-3. La Balise, Mississippi River, 1822.

the newly formed United States. The removal of the British from the Gulf coast was desirable to the former colonies.

5.2 Shipwreck Patterns - Early to mid 18th Century

During this period there is an increased number of non-Spanish wreck sites (Table 5-1). This is a realistic expectation as French and British colonies were being established. Further settlement of the Louisiana territory by France drew both Spanish and French trade, although vessel numbers rarely exceeded a dozen a year (Surrey 1916). As the century wore on, Spanish shipping used more and more vessels of foreign build (Peterson 1975).

TABLE 5-1
Losses in the Louisiana Area, ca. 1700-1800

VESSEL	YEAR	LOCATION	SOURCE
LA SAINT ANTOINE	1705	off Mobile	Mistovich 1983
L'AVENTURE	1708	___	A.N.,C.
bateau	1711	Mobile - Vera Cruz	A.N.,C.
brigantin	1711	Martinque - Louisiana	A.N.,C
LA JUSTICE	1715	Mobile	A.N.,C.
LA MARIEBAL	1721	?	A.N.,C.
bateau	1725	Horn Island	A.N.,C.
LA BELLONE	1725	Dauphin Island	A.N.,C.
LA PRINCE DE CONTY	1731	La Balise?	A.N.,C.
LA VIGILENTE	1732	Chandeleur Islands	A.N.,C.
LE SAINT LOUIS	1733	Mobile?	A.N.,C.
bateau	1734	?	A.N.,C.
brigantin	1735	off Cuba	A.N.,C.
LA MARGUERITE	1737	Horn Island	A.N.,C.
brig	1737	near Mobile, island	A.N.,C.
LA LOUISIANE	1738	La Balise	A.N.,C.
LA NOTRE DAME DE BON SECOURS	1739	Dauphin Island	A.N.,C.
L'ATLAS	1740	?	A.N.,C.

bateau	1741	West Bay?	A.N.,C.
?	1742	Coast of Louisiana	A.N.,C.
bateau	1755	Mississippi River Bar	A.N.,C.
LE CONSTANCE	1766	Chandeleur Islands	Pearson 1981
NUESTRA SENORA DEL AMPARO	1772	Mouth of the Mississippi River	Marx 1971
LA NAVIGATOR	1821	Chandeleur Islands	Marx 1971

There was greater variation in vessel type and capacity. This was a direct corollary to the above. For a Spanish fleet of 1733, Peterson (1975) lists Genoese, Dutch, English, and American built ships ranging from 400 to 900 tons. Surrey (1916) discusses French vessels of types known as falouches, sloops, barques with a few ketches and frigates of over 100 tons.

Shipwrecks still cluster at the Straits of Florida but now shipwrecks appear in the northeastern Gulf area (Mississippi River, Chandeleurs and coastal barriers) with the establishment of Biloxi, Mobile, and New Orleans by the French and Pensacola by the Spanish.

The data show a pattern of loss to either side of the Mississippi deltaic tip (Figures 5-4 and 5-5). The data suggest strandings due to storms as one principal type of wrecking process rather than open water foundering (Table 5-2). The heavy modern traffic pattern developed slowly from the 18th century with losses distributed to the east of the Balise (Northeast Pass) and along the Chandeleurs as would be expected for the French Colonial era. Only with the development of the Trans-Sabine coast southward to the Mexican border in the 19th century and the Louisiana coast west of the delta did shipwreck density in the west Gulf begin to approach that seen for eastern waters.

TABLE 5-2
Historical Reports on Gulf Hurricanes; French and Spanish Data

YEAR	LOCATION	VESSEL LOSSES	SOURCE
1722	la Louisiane	several small craft (chaloupes)	A.N.,C., Sér C^{13}, vol. vi, fol. 340
1732 (August)	la Louisiane	Spanish frigate at Chandeleurs, *la Vigilante*	A.N.,C., Sér. C^{13}, vol. xvi, fols. 7 (Feb 5, 1733)
1734	Mobile (New Orleans-Mobile)	none-severe losses in storm April 1 off Ship Island (many others destroyed)	A.N.,C. Sér C^{13}, vol. xvii, fols 53-54
1735	off Havana; S.E. Gulf of Mexico	2 vessels (French) before the end of the year...hurricane	A.B.N. Fr., vol. 10769, fol 88
1738	la Louisiane	4 ships wrecked by storms (hurricanes)	A.N.,C., Sér. C^{13}, vol. xxii fols. 202-203, 221
1740 (Sept)	la Louisiane Mobile-New Orleans	large bateau lost, boats of all kinds	A.N.,C., Sér. C^{13}, vol. xxvi, fols. 127-130
1750	la Louisiane	large storm at harvest (29 September 1750)	A.N.,C., Sér. C^{13}, vol. xxxvi, fol. 347
1752	la Louisiane	numerous storms and hurricanes - in fall harvest	A.N.,C., Sér. C^{13}, vol. xxxvi, fols 228, 271
1755	mouth of Mississippi River	1 vessel destroyed by storm (hurricane)	A.N.,C., Sér. C^{13}, vol. xxxix fol.
1766	Pensacola	Fleet wrecked; *Le Constance* lost on Chandeleurs	Tannehill 1956; Pearson 1981

1780	Straits of Florida S.E. Gulf of Mexico to Miss. River (N.E. half of Gulf of Mexico (formed in Gulf)) Oct. 20: 100 miles SSE of Miss. R. delta	19 ships lost (locations coincide with similar storm Oct 21) near 25°27'N 91°7'W, 26°42'N 86°11'W	Admiral Jose Solano in Millás 1968; Tannehill 1956

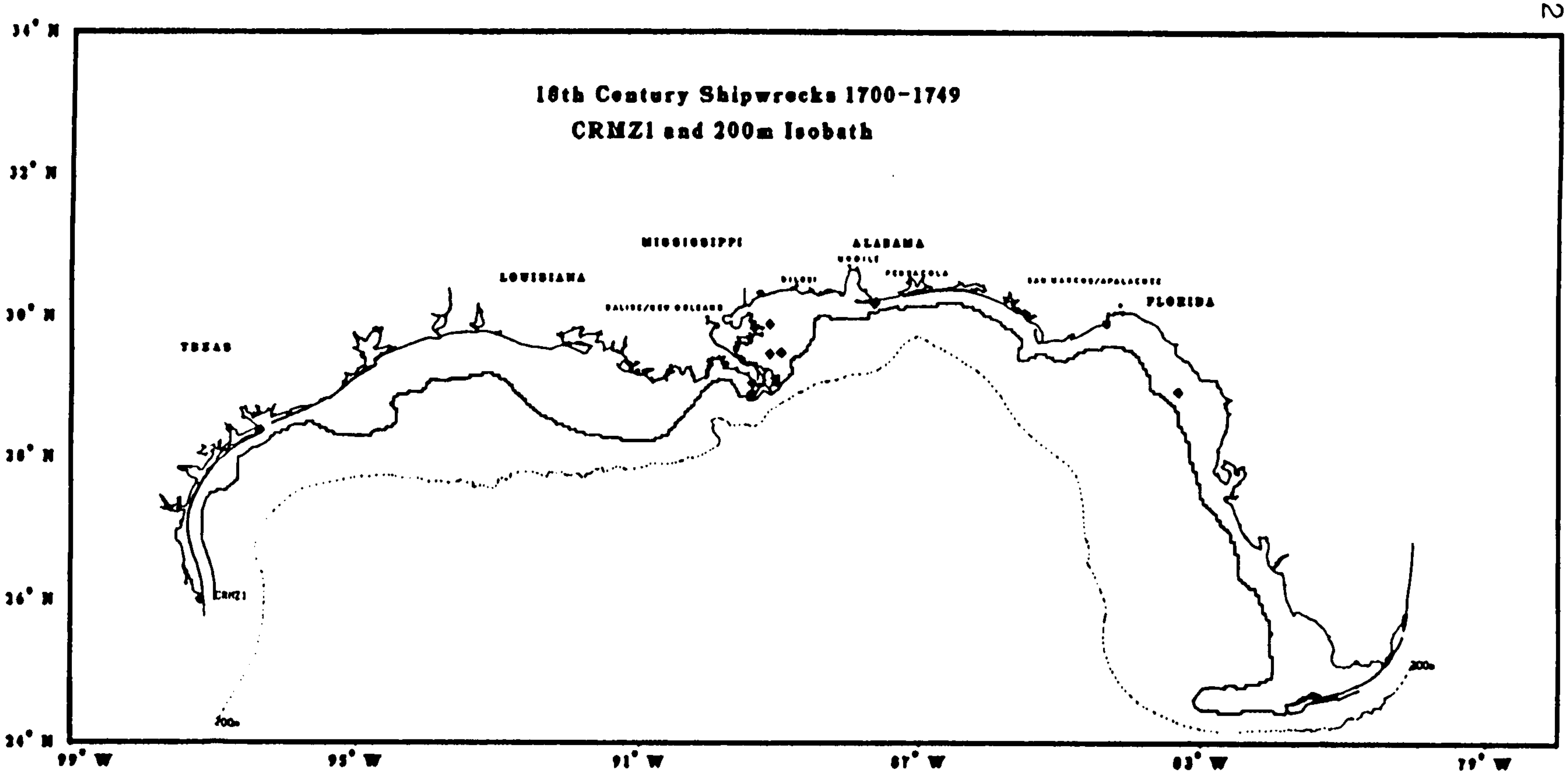


Figure 5-4. Shipwreck positions, 1700-1749.

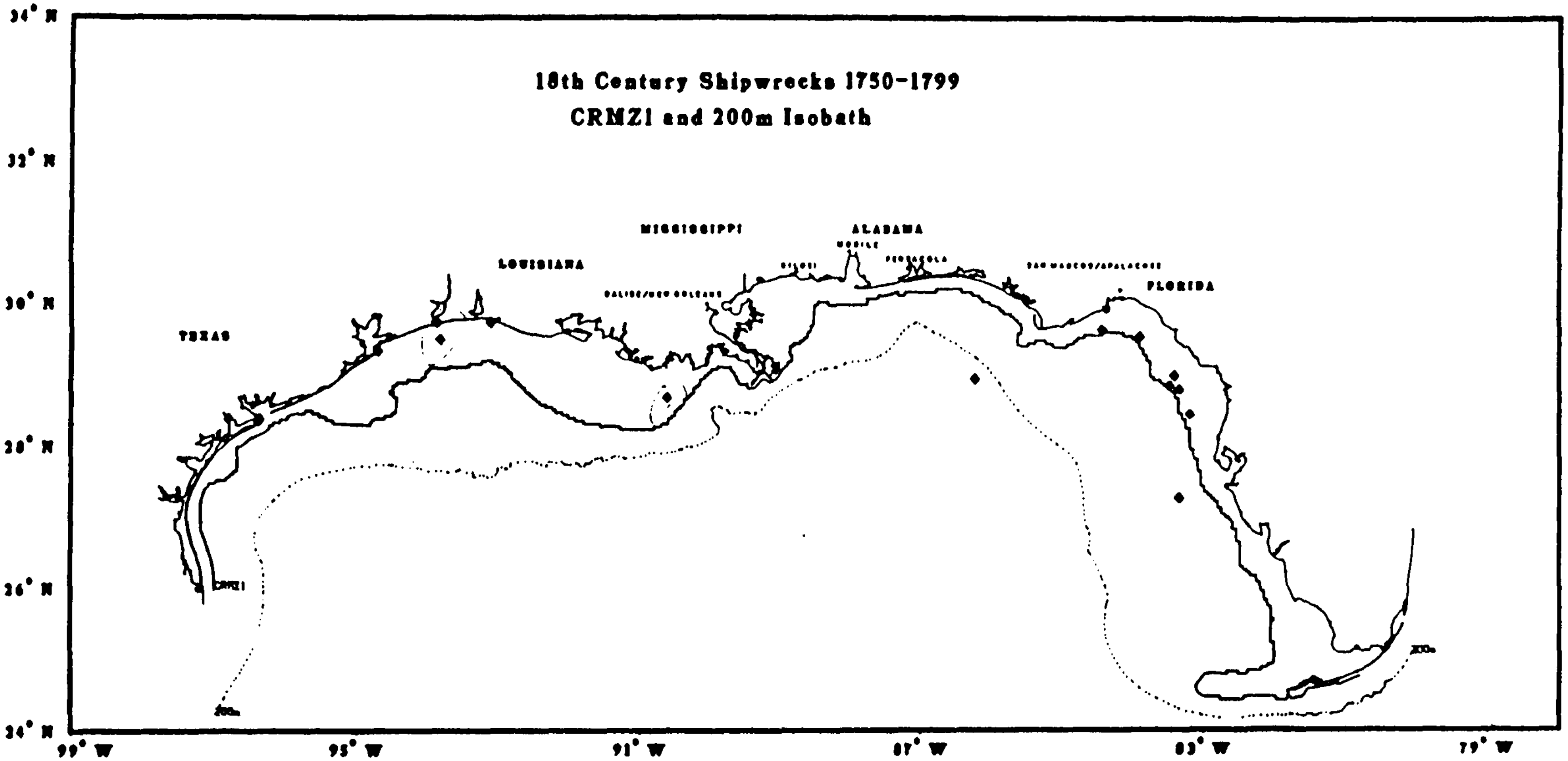


Figure 5-5. Shipwreck positions, 1750-1799.

6.0 INSTRUMENTAL SURVEY

6.1 Equipment Used

A previously unknown marine archaeological site is the subject of this survey. The site is situated south of the north end of the Chandeleur Islands approximately 1.6 km offshore and consists of a 13.5 x 10.0 x 1.1 m pile of ballast rocks with six iron cannon scattered on top of the rocks (Figure 6-1). The surrounding bottom sediments are a fine grained sand/silt with rippled wave texture. The survey vessel used was a 17 m fiberglass charter boat

For this survey an area 1 km^2 was defined around the known position of the ballast pile. This was accomplished by measuring the distance between two towers erected for Del Norte microwave remote transponders on the nearby Chandeleur Islands. From that baseline (2156 m) and the position of the ballast pile, the survey area was defined such that the ballast pile was roughly in the middle of a 1000 m by 1000 m area. The 2156 m baseline on the island was oriented approximately 15° west of north and was used as a template to align the 20 north/south survey lines which ran with a 50 m interval between each line (Figure 6-2). A second survey was set up for 10 m lanespacing in the immediate area of the ballast pile for which the survey area was 300 m east-west and 600 m north-south, centered around the ballast pile (Figure 6-3). Lines with an "N" were traversed going from the south end to the north end of the survey area. Lines with a "S" were run in the opposite direction. The sequence in which the lines were completed (1S, 6N, 2S, 7N, etc.) was the most efficient with respect to time and resources, allowing a smooth, quick transition from line to line. This also kept us from immediately going over our own wake. This was necessary because air entrained into the surface water by the boat's prop was detectable by side-scan for at least 15 minutes.

The survey lines were run using a Del Norte model 542 Distance Measuring Unit from which a monitor was connected to the bridge of the survey vessel which indicated heading, distance and direction off the selected course, speed and distance to end of line. The position of the survey

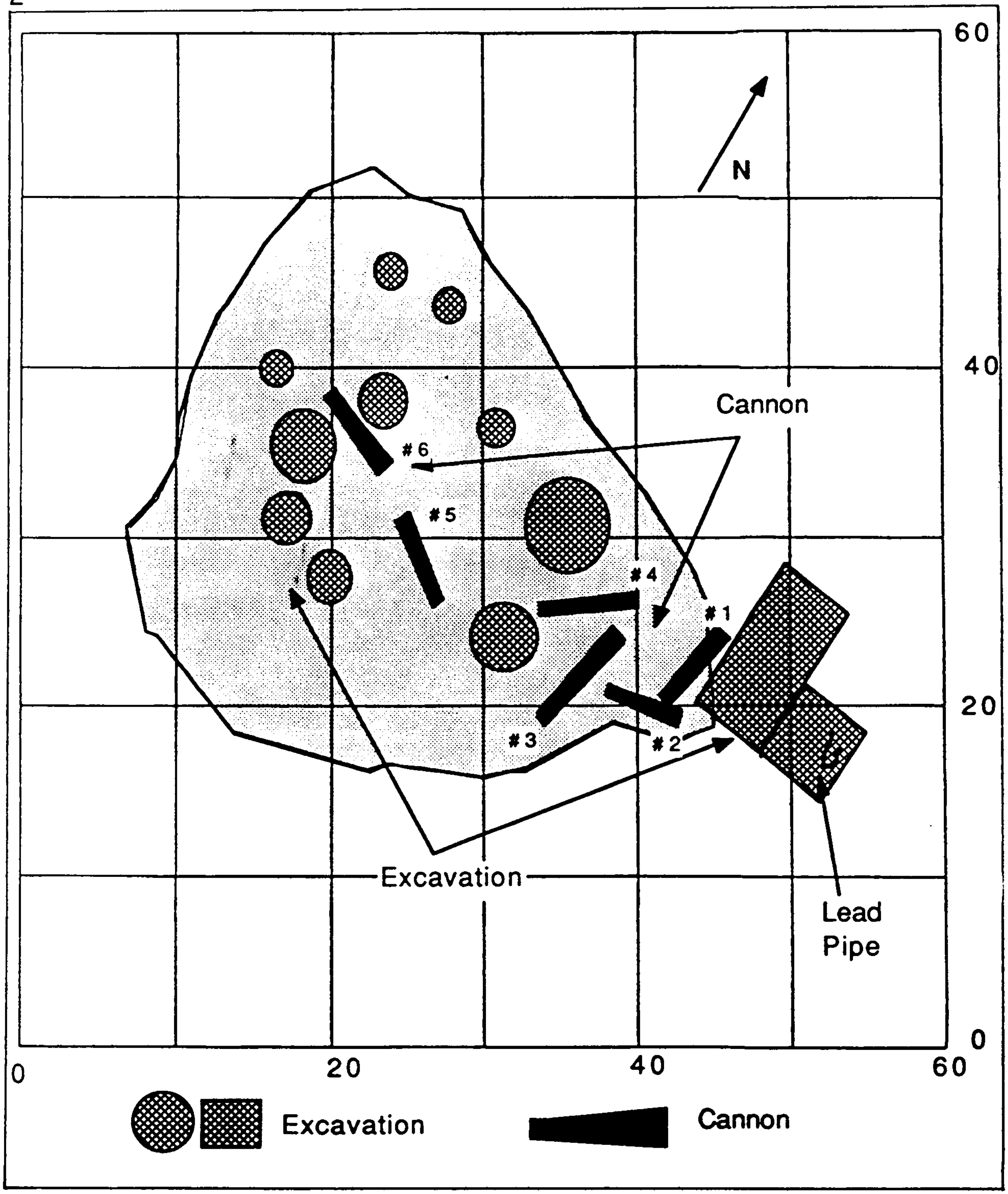


Figure 6-1. Site Map showing areas and numbered cannon. Grid is 3 m (10 feet)

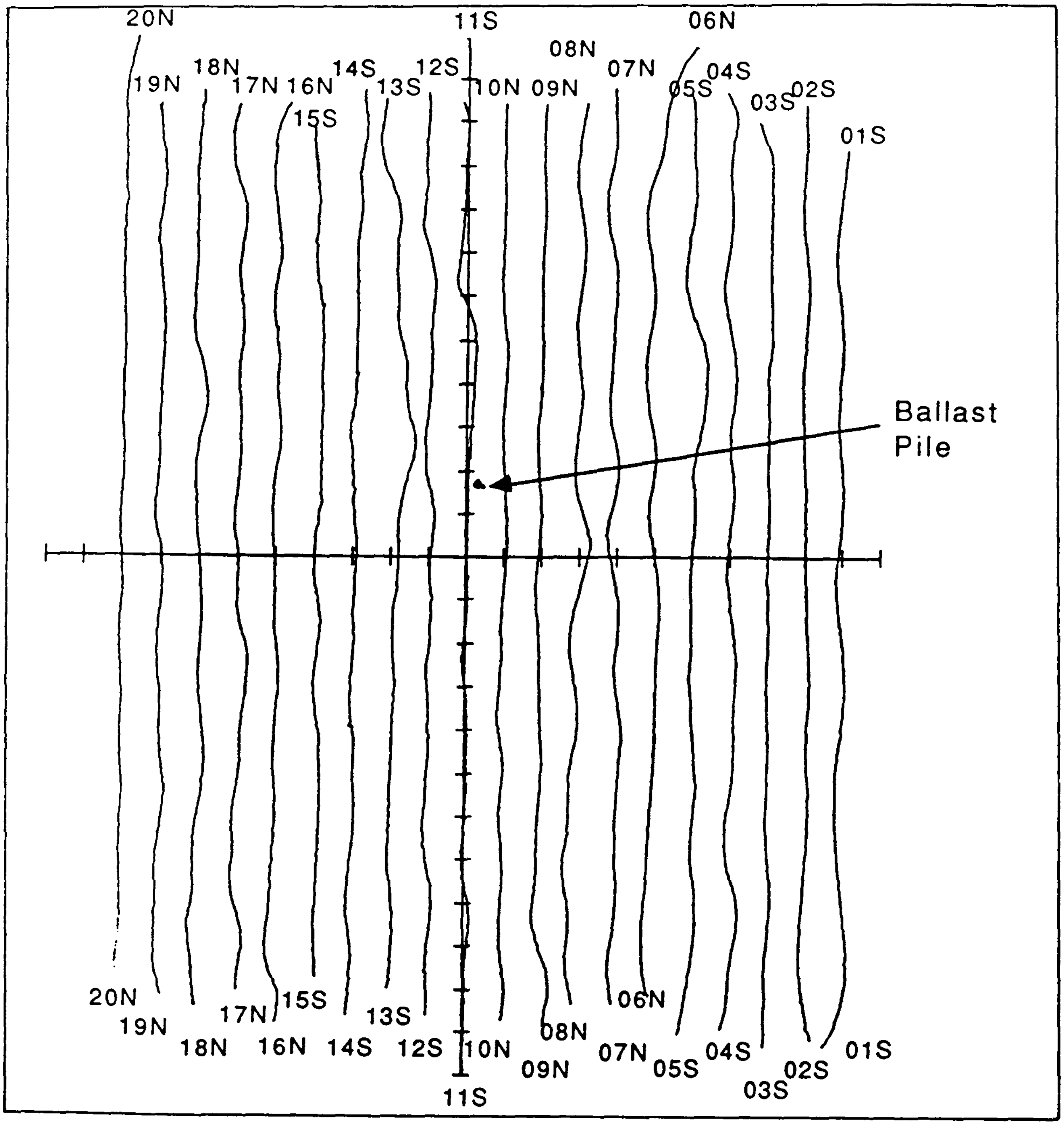


Figure 6-2. 50 meter lanespacing showing lines used in making the contour image.

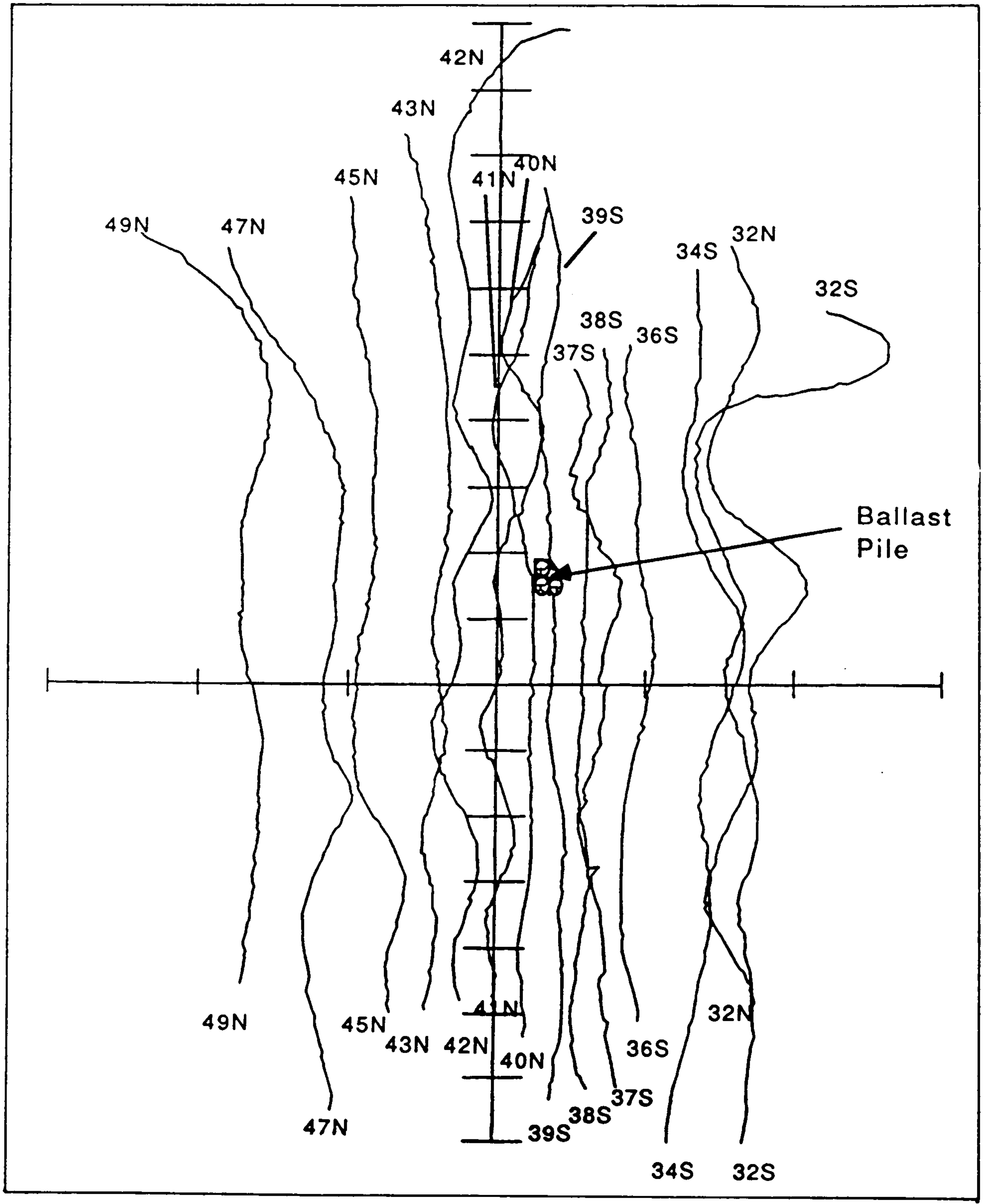


Figure 6-3. 10 meter lanespacing survey lines. Grid lines cross at x,y 1900,500 with intervals of 50 meters.

vessel was calculated relative to the master microwave remote which was mounted on the middle of the vessel at a distance of 7.8 m from the stern. Since the ballast pile was 1.6 km offshore, no position in the survey area was ever more than 3.5 km from either of the baseline remotes, which together with the length of the baseline guaranteed optimum operating conditions for navigation.

The magnetics were measured using an EG&G-Geometrics model 866 magnetometer and marine towfish. The sampling rate was set at one second intervals with data being recorded on both electrostatic strip chart paper on 10/100 gamma scale setting, and onto the disk of a micro-computer. The computer simultaneously recorded the magnetic data with the time and the position of the master microwave remote mounted on the survey vessel. Thirty-one meters of magnetometer cable was deployed over the stern of the vessel to insure that interference from the vessel would not affect the readings of the magnetometer. Since the water depth was 7 m or less, no effort was made to measure the depth of the magnetometer sensor above the bottom as it was less than the required 6 m from the bottom.

The bottom was monitored for anomalies using an EG&G model 260 Side Scan Sonar with a model 242-TD Dual Frequency Towfish. The towfish was deployed over the starboard side of the survey vessel at a point perpendicular to the navigation remote. The transducers of the side-scan operate at either 100 or 500 khz frequency, with the resulting image being corrected for boat speed, towfish depth and slant range. The only problems encountered with this survey arrangement were caused by the transducer of the fish locater used by the survey vessel, which was detected by the side-scan and appeared as interference on the hard copy. This problem was remedied by running with the fish locater turned off.

The vessel position was recorded upon the printout of the side-scan when an event mark was triggered. This was accomplished by the use of an event generator which simultaneously triggered an event mark for both the side-scan and the magnetometer at 20 second intervals, or roughly every 45 m at the 5.5 - 6.0 knot survey speed.

6.2 Magnetics

The following (Table 6-1) is a list of the magnetic anomalies recorded during the survey. They are listed in ascending order with the 50 m lines first (1S - 20N) followed by the 10 m lines (32N - 49N). The magnetic anomalies are described as they occurred during the run of the line; hence a north bound line has increasing y-coordinate values and a south bound line has decreasing. Each anomaly is described by the maximum magnetic value, measured relative to the background value, in gamma's or nanotesla's, followed by the duration of the event in seconds, with the position of the anomaly, in parenthesis, relative to the site map coordinates. Dipoles present in broad anomalies are listed with their own position. Each of these lines has two figures associated with it that are found in chronological order in Appendix A. One figure is the raw magnetic data recorded by the computer during the survey, while the other is that data reduced to positive and negative values relative to a calculated baseline.

Table 6-1
Magnetic Anomalies

Line #		Magnetics
01S		Nothing
02S		Nothing
03S	1	Dipole -4/9γ , 4 sec. duration, at (2304,934)
	2	-10γ, 2 sec, (2301,562)
	3	Broad anomaly with dipole, 10/-26γ, 22 sec, (2297,344)
	4	Dipole -2/16γ, 4 sec., (2297,193)
04S	1	8γ, 3 sec., (2248,768)
	2	Dipole -6/3γ, 8 sec., (2253,666)
	3	12γ, 2 sec., (2252,543)
	4	-7γ, 2 sec., (2258,364)

	5	-8γ, 2 sec., (2255,316)
	6	Dipole -3/6γ, 5 sec., (2259,67)
05S	1	Dipole -7/3γ, 5 sec., (2203,919)
	2	10γ, 3 sec., (2197,871)
	3	11γ, 3 sec., (2192,845)
	4	Broad anomaly -10γ, 12 sec. (2218,696 - 2191,808)
	5	Broad anomaly 8γ, 8 sec., (2212,648 - 2216,675)
	6	Dipole 7/-3γ, 4 sec., (2198,427)
	7	10γ, 3 sec., (2199,328)
06N		Nothing
07N	1	Broad anomaly with imbedded dipoles, max. -33γ, 80 sec., (2094,54 - 2100,214). Dipole -18/-3γ, 3 sec., (2100,106). Dipole -33/9γ, 3 sec., (2100,133)
	2	Broad anomaly -9γ, 10 sec., (2101,324 - 2097,353)
08N	1	Dipole -8/3γ, 5 sec., (2031,127)
	2	23γ, 5 sec., (2034,170)
	3	14γ, 7 sec., (2037,216)
	4	8γ, 6 sec., (2049,306)
	5	Dipole -2/11γ, 5 sec., (2045,350)
	6	Broad anomaly with imbedded dipoles, max. -25γ, 45 sec., (2042,427 - 2044,615). Dipole 1/-24γ, 3 sec., (2062,525)
	7	Dipole -2/12γ, 3 sec., (2046,632)
09N	1	Dipole 2/-6γ, 4 sec., (2008,-22)
	2	Broad anomaly with imbedded dipole, max. -8γ, 35 sec., (1996,142 - 2000,235). Dipole -8/1γ, 3 sec., (1995,159)
	3	Broad anomaly, max. -10γ, 33 sec., (1993,471 - 1999,570)
	4	Dipole -6/2γ, 4 sec., (2000,717)
10N	1	Broad anomaly with imbedded dipole, max. -13γ, 24 sec., (1949,111 - 1951,260). Dipole 10/-13γ, 7 sec.

		(1951,127)
	2	Dipole 8/-2γ, 4 sec., (1945,348)
	3	Broad anomaly in area of ballast pile, max -25γ, 65 sec., (1951,473 - 1948,640)
	4	Dipole -2/9γ, 3 sec., (1951,688)
11S	1	4γ, 2 sec., (1905,634)
	2	4γ, 4 sec., (1902,570) Both of these anomalies are questionable and can only be considered due to very low line noise and their proximity to the ballast pile.
12S	1	5γ, 4 sec., (1852,697)
	2	7γ, 3 sec., (1846,646)
13S		Nothing
14S	1	Dipole -1/7γ, 3 sec., (1754,844)
	2	-5γ, 3 sec., (1754,770)
	3	13γ, 3 sec., (1746,650)
15S		Nothing
16N	1	Broad anomaly, max. -7γ, 20 sec., (1657,-11 - 1640,45)
17N		Nothing
18N	1	-37γ, 2 sec., (1546,559)
	2	-11γ, 2 sec., (1544,591)
	3	-37γ, 2 sec., (1542,817)
19N	1	-4γ, 7 sec., (1500,12)
	2	Dipole 3/-5γ, 4 sec., (1501,786)
	3	-8γ, 5 sec., (1499,806)
	4	Broad anomaly, max. -8, 13γ, sec., (1496,835 - 1494,870)
20N	1	-11γ, 9 sec., (1452,467)
	2	-12γ, 3 sec., (1452,603)

32N	1	Dipole 26/-6γ, 15 sec., (1987,448 - 1985,505)
32S	1	Dipole -29/23γ, 12 sec., (1981,462 - 1977,498)
34S	1	Dipole -8/98γ, 20 sec., (1972,445 - 1983,529)
36S		Nothing
37S	1	5γ, 5 sec., (1926,670)
	2	-4γ, 9 sec., (1940,570 - 1934,603)
38S	1	-11γg 14 sec., (1928,544 - 1930,597)
39S	1	Dipole -13/55γ, 20 sec., (1919,544, - 1918,602)
40N	1	Dipole 20/-10γ, 25 sec., (1912,560 - 1909,605)
	2	Dipole -11/23γ, 10 sec., (1910,651 - 1915,692)
	3	Dipole 1/-9γ, 12 sec., (1906,732 - 1903,785)
41N	1	14γ, 5 sec., (1899,283)
	2	-2γ, 11 sec., (1905,628 - 1900,675)
	3	2γ, 9 sec., (1909,793 - 1913,834)
42N	1	3γ, 7 sec., (1892,336)
	2	-16γ, 5 sec., (1883,423)
	3	Dipole 29/-14γ, 12 sec., (1895,623 - 1896,653)
	4	29γ, 3 sec., (1883,878)
43N	1	-6γ, 5 sec., (1879,361)
	2	Dipole 27/-51γ, 17 sec., (1881,593 - 1883,648)
45N	1	8γ, 3 sec., (1863,385)
	2	3/-2γ, 8 sec., (1858,698 - 1854,754)
47N	1	Dipole -2/4γ, 5 sec., (1850,406)
49N	1	Dipole -17/8γ , 5 sec., (1815, 274)

The magnetic data from the 50 m and 10 m surveys were used to generate a series of contour maps designed to illustrate what can be seen and what is missed when using 100, 50 or 10 m lanespacing. The 100 m lanespacing was simulated by taking every other 50 m line and using those data to generate a contour map from both the odd and even 50 m lines. A subarea was defined in the immediate area of the ballast pile to further illustrate the differences of lanespacing. This subarea was defined by the data within the area outlined by the box created by x,y coordinates 1750,400 as lower left, to 2150,800 upper right. The ballast pile is located roughly in the center of this 400 m by 400 m area, which we felt was sufficient to isolate anomalies that could be associated with the ballast pile (Figures 6-4 & 6-5). For this subarea, contour maps were generated for 100, 50 and 10 m lanespacing.

6.2.1 Magnetics: Subarea

As can easily be seen, and as would be logically expected, the greatest amount of detail is associated with the 10 m lanespacing data (Figure 6-6). The anomalies are more numerous, have greater amplitude and are more clearly defined, with a very distinct anomaly associated with the ballast pile. There are also several distinct anomalies within 100 m of the ballast pile to the southeast and northwest. These may be associated with the ballast pile. Without groundtruthing there is no way to be certain of that supposition. But if they are associated with the ballast pile, they certainly must be investigated to determine if more information concerning the archaeological identity of this site can be gained.

The 50 m spacing contour map (Figure 6-7) provides less detail, with broad shallow anomalies to the east and southeast of the ballast pile which is identified with a broad shallow contour just to the north of the actual site. Gone are the intense anomalies of the 10 m map which would clearly draw attention to the ballast pile as a point for further interest. The sphere of interest is instead shifted to the more promising area south

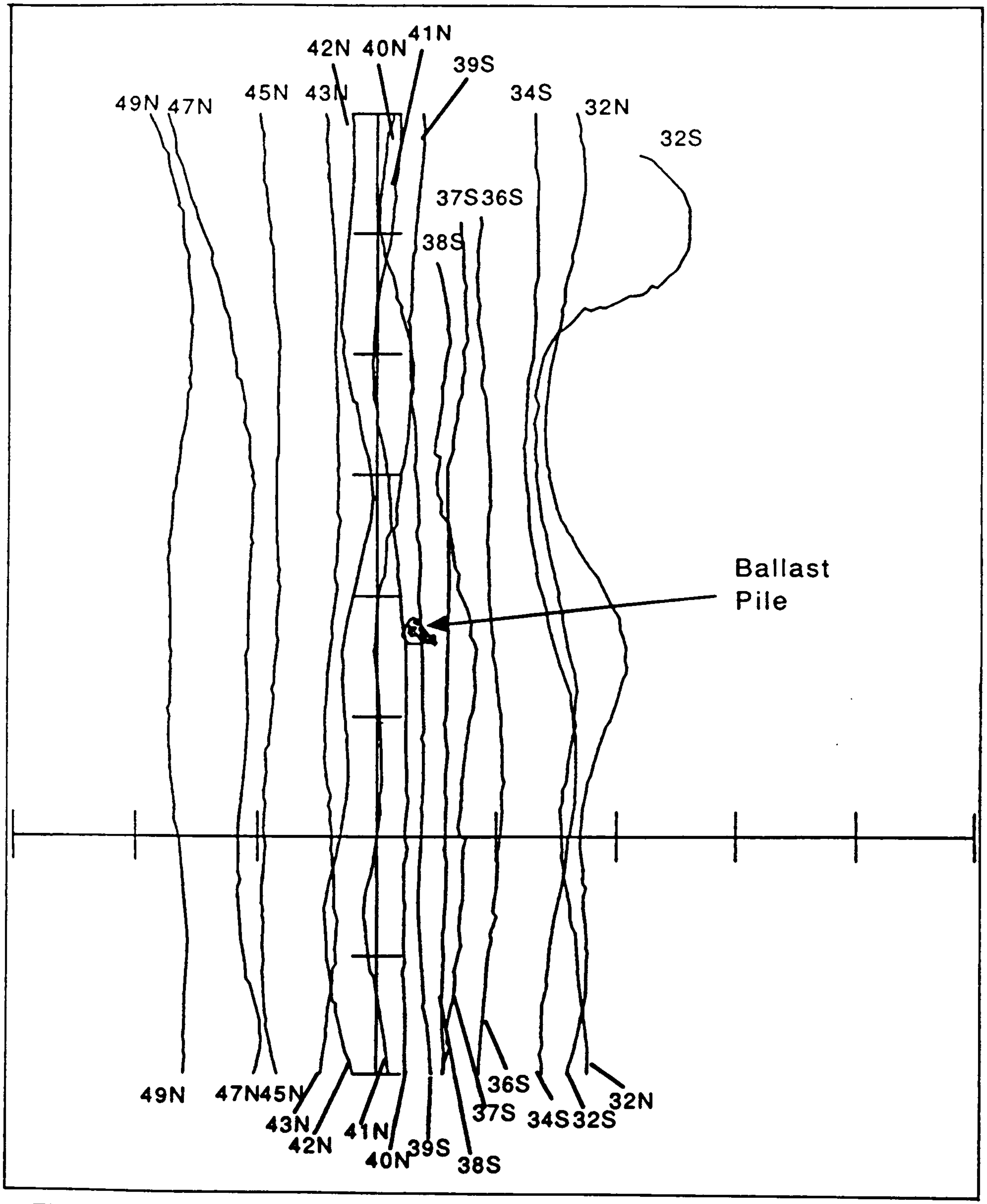


Figure 6-4. 10 meter lanespacing for the subarea around the ballast pile. The scale lines cross at x,y 1900,500 with 50 meter intervals.

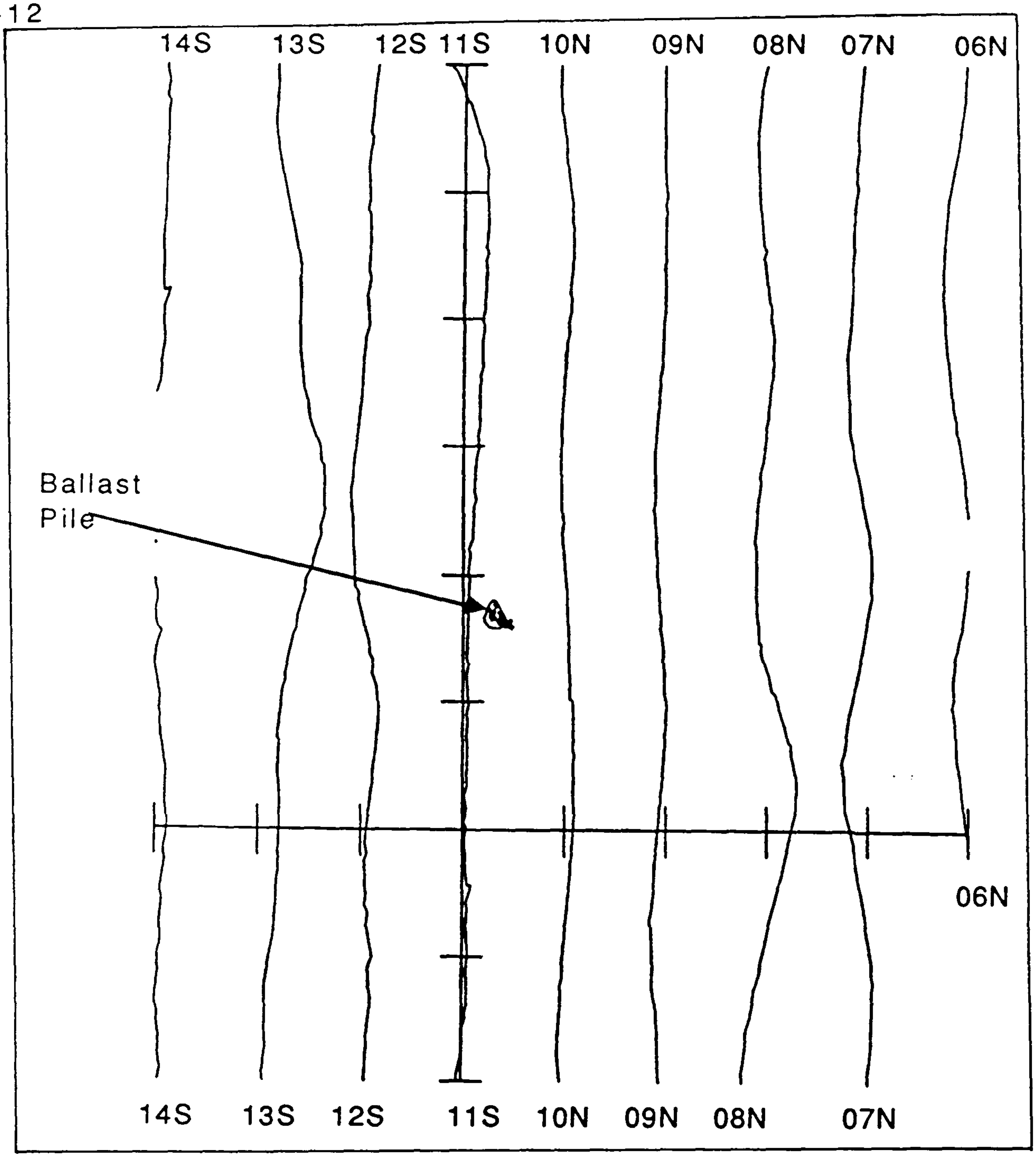


Figure 6-5. 50 meter lanespacing for the subarea around the ballast pile. The scale lines cross at x,y of 1900,500 with 50 meter intervals.

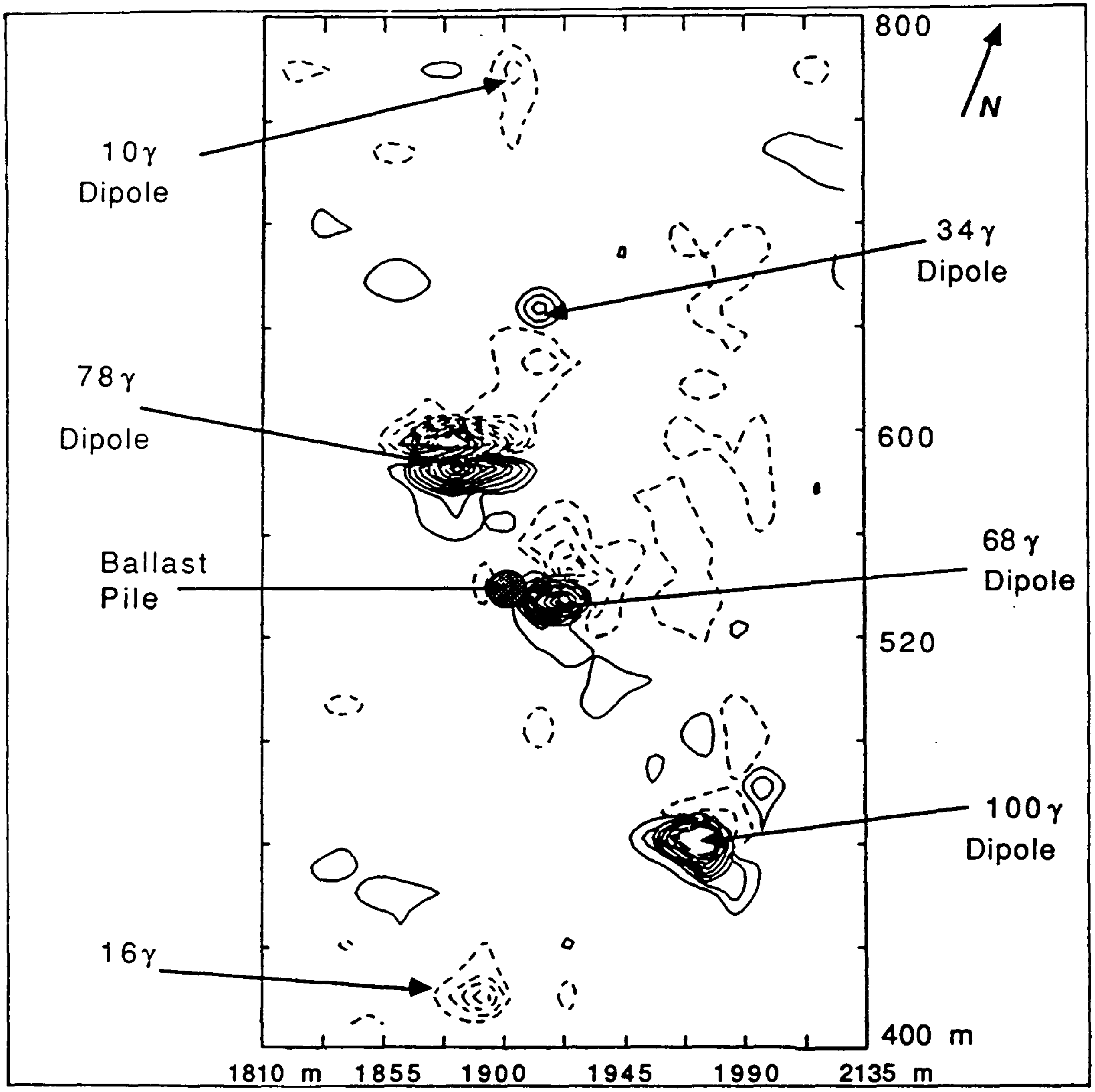


Figure 6-6. Contour map of subarea from 10 meter lanespacing.

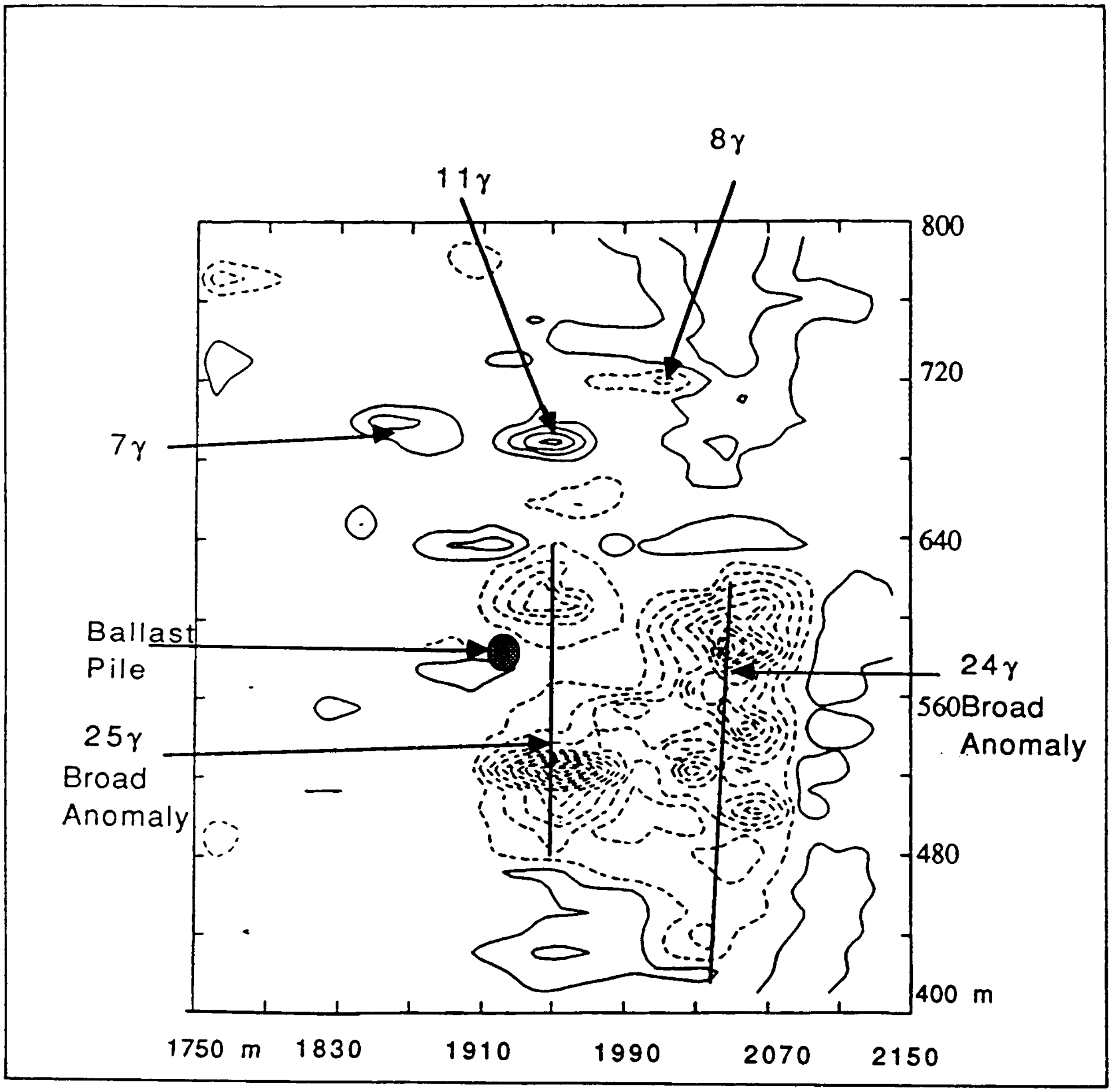


Figure 6-7. Contour map of subarea from 50 meter lanespacing.

and east of the ballast site. With only the magnetic data, it is not definite that the ballast pile site would require further investigation.

The 100 m lanespacing contour maps (Figures 6-8 & 6-9) illustrate the hit or miss aspect of larger lanespaces. The odd numbered lines (Figure 6-8) have virtually no magnetic structure, while the even numbered lines (Figure 6-9) have the same patterns as the 50 m spacing, with the same area of interest being to the southeast of the ballast site.

6.2.2 Magnetics: Total Area

Since only the 50 m lanespacing lines were run over the total area, only 50 (Figure 6-10) and 100 m (Figures 6-11 & 6-12) contour maps are discussed.

These contour maps further illustrate the hit or miss characteristics seen in the subarea contours, with the areas of magnetic interest still to the south and east. At the greater areal coverage of these maps there appears to be a line running north-south over the ballast pile separating the area inshore, where there are few magnetic anomalies, from the area offshore, where there are many. For a further discussion of this anomaly alignment see Section 6.4.2.

6.3 Side-scan Sonar

Table 6-2 lists the side-scan sonar anomalies. The lines are ordered in the same manner as Table 6-1. The anomaly is described with its perpendicular distance from the survey vessel and its position in survey area coordinates. If any magnetic anomalies have a similar position then they are also mentioned.

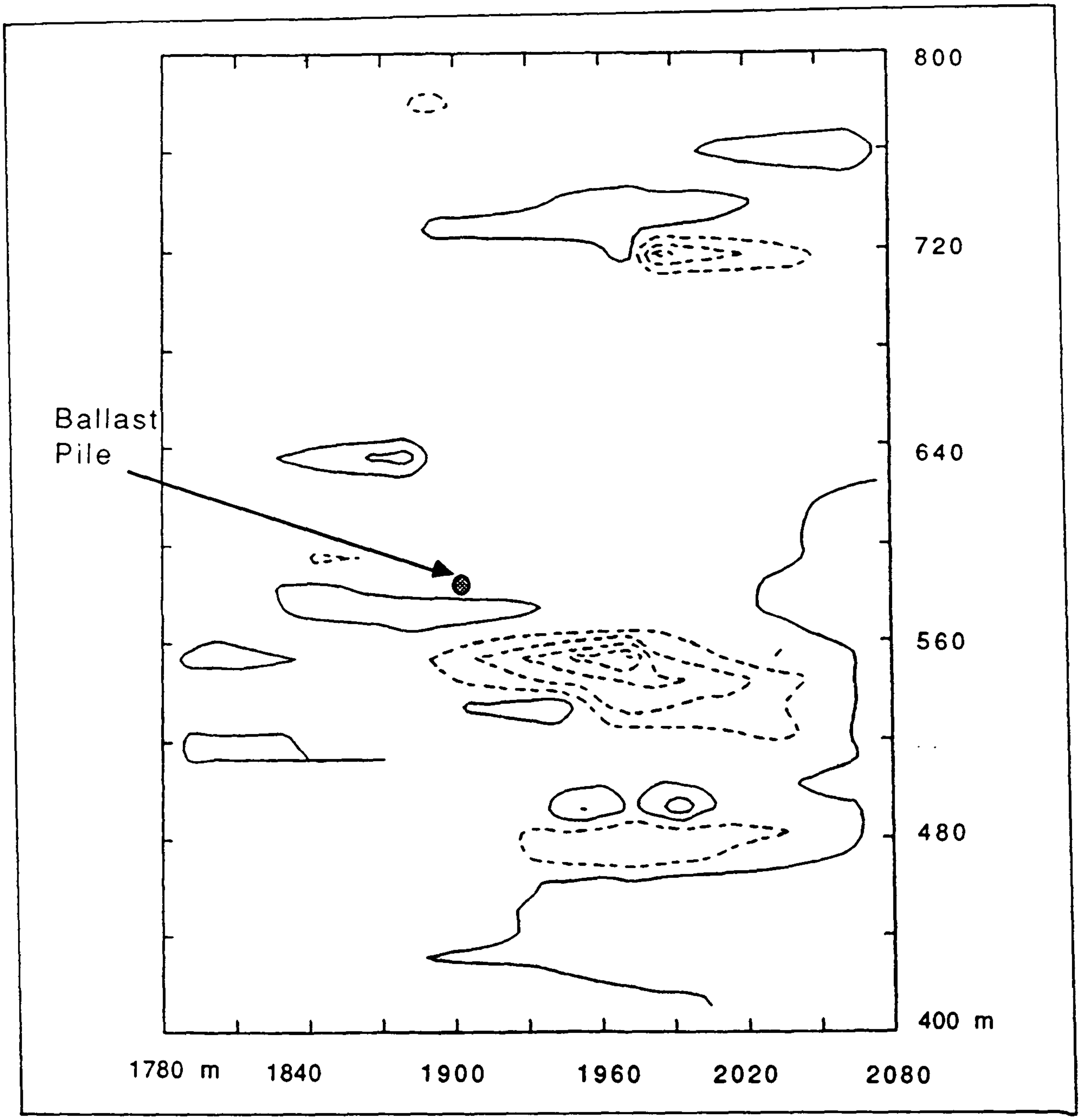


Figure 6-8. 100 meter lanespacing contour map from odd 50 meter lanes.

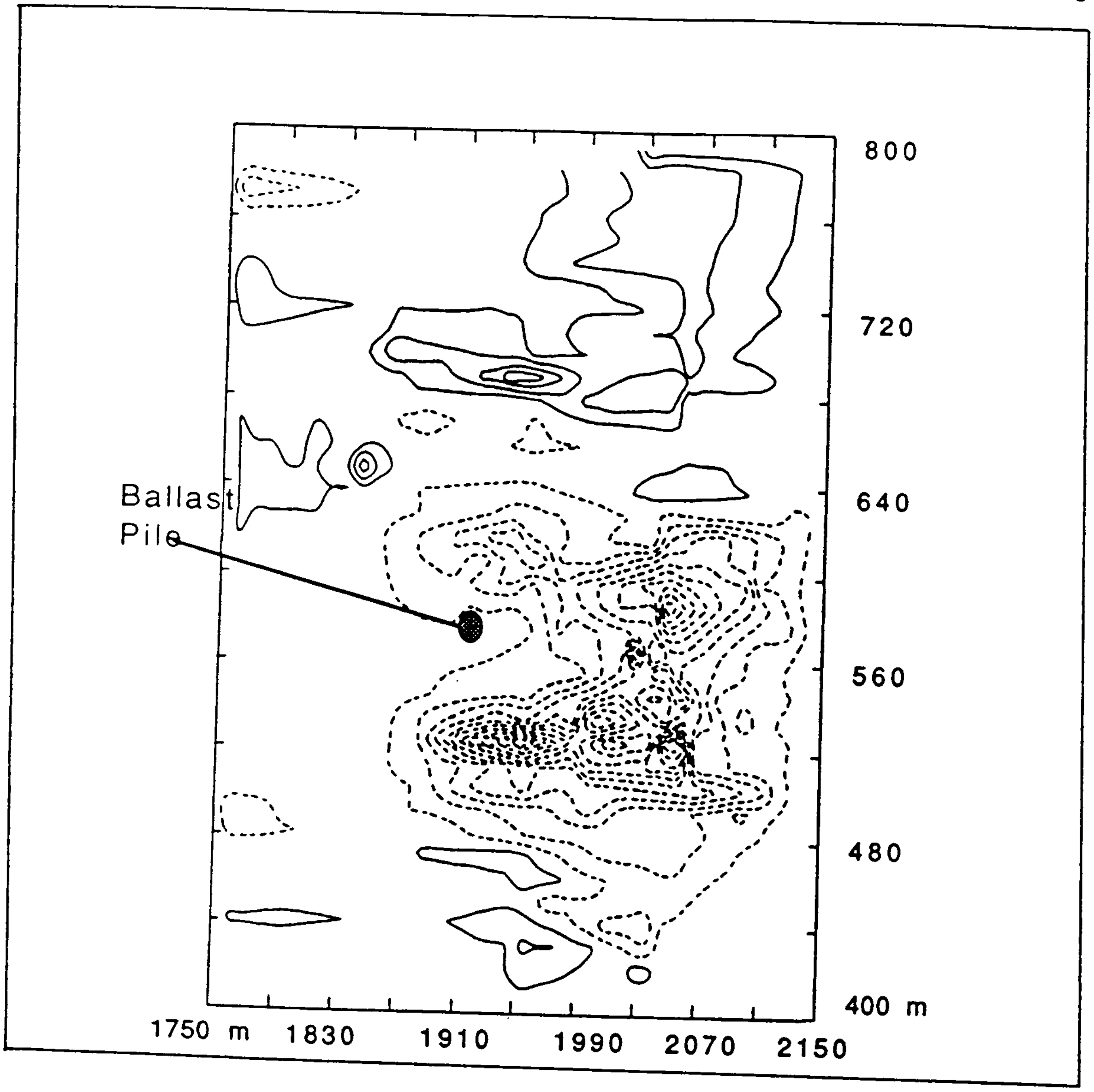


Figure 6-9. 100 meter lanespacing contour map from even 50 meter lanes.

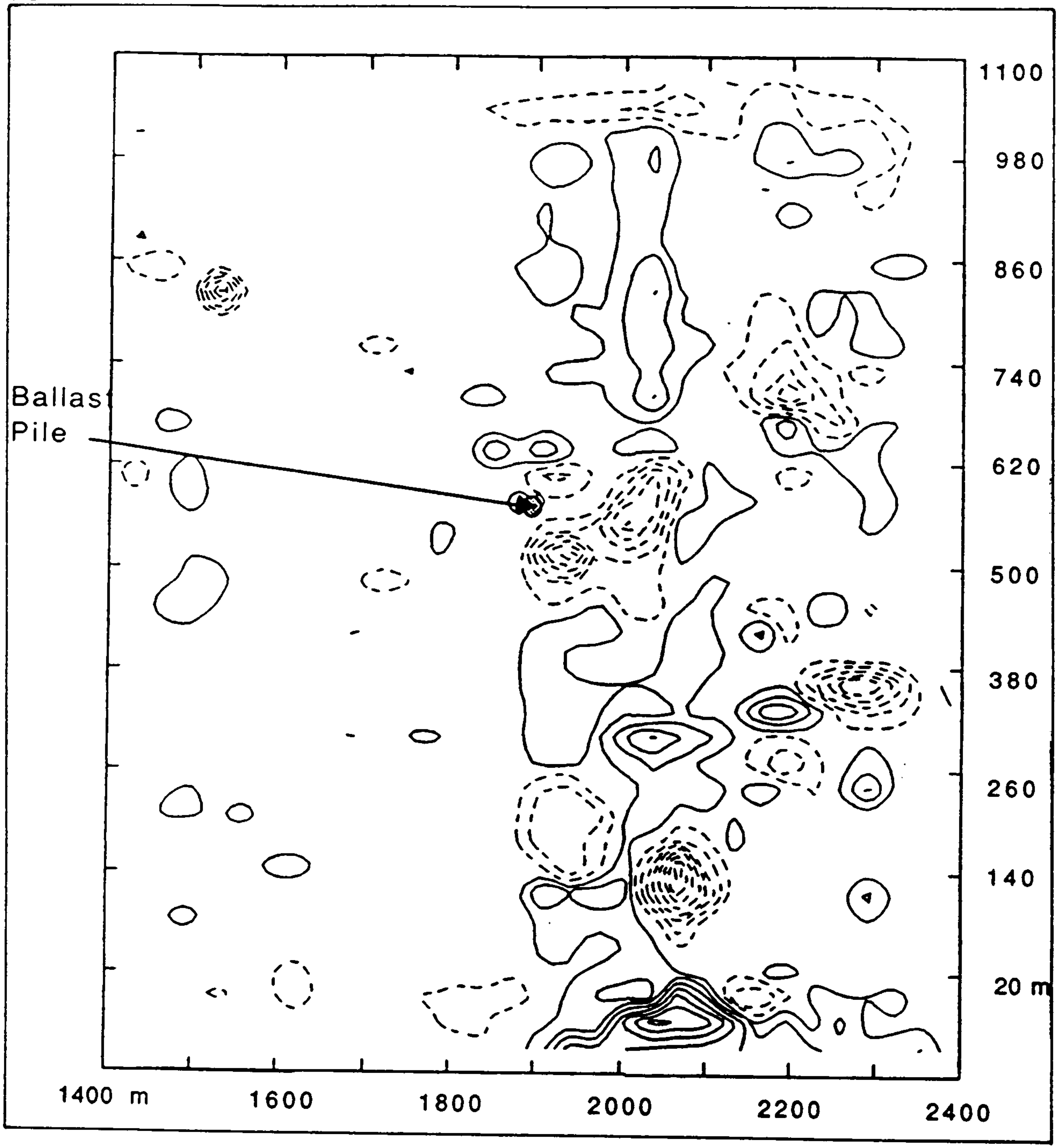


Figure 6-10. Contour map of survey area using 50 meter lanespacing.

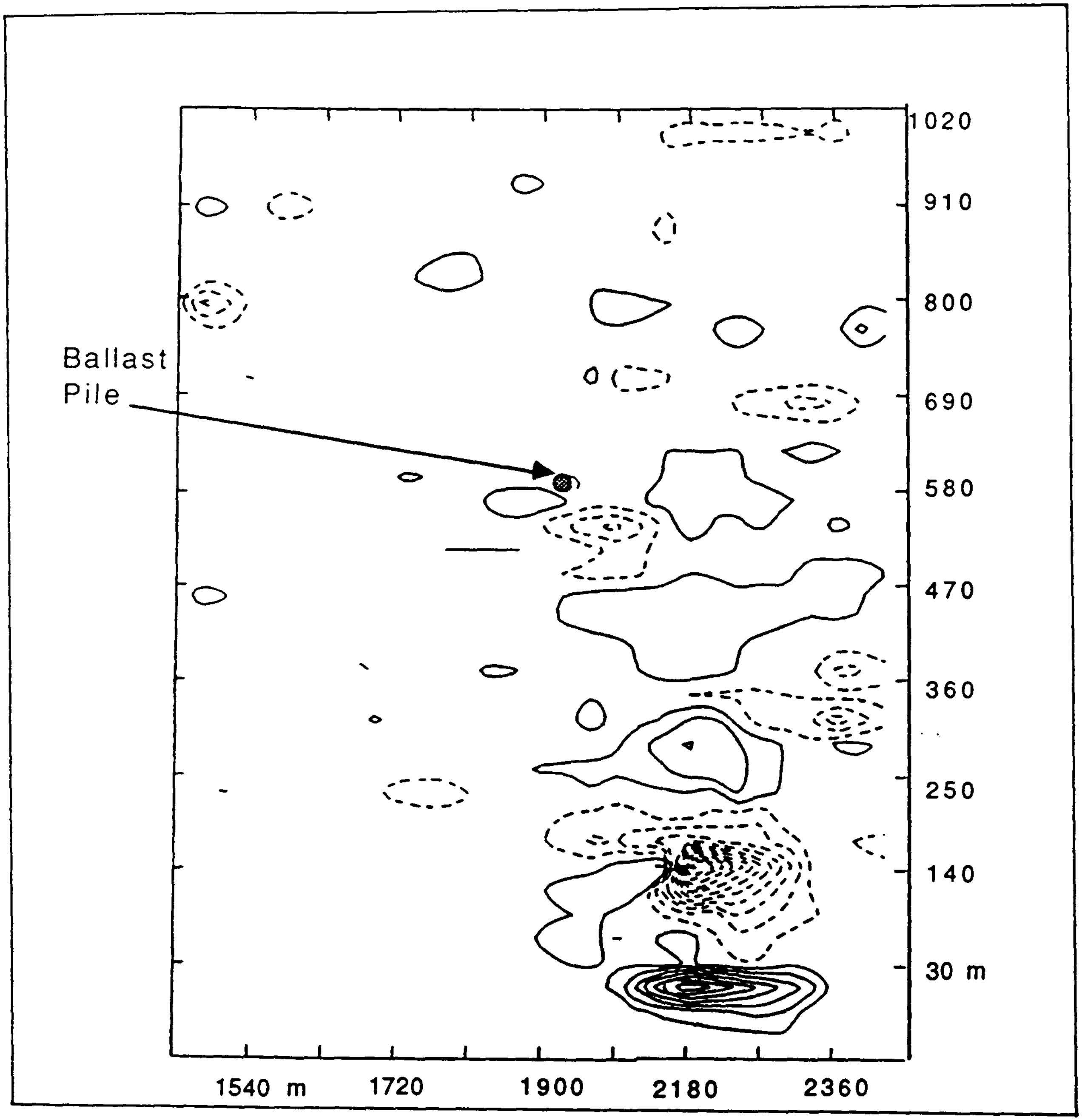


Figure 6-11. 100 meter lanespacing contour map of survey area from odd 50 meter lanes.

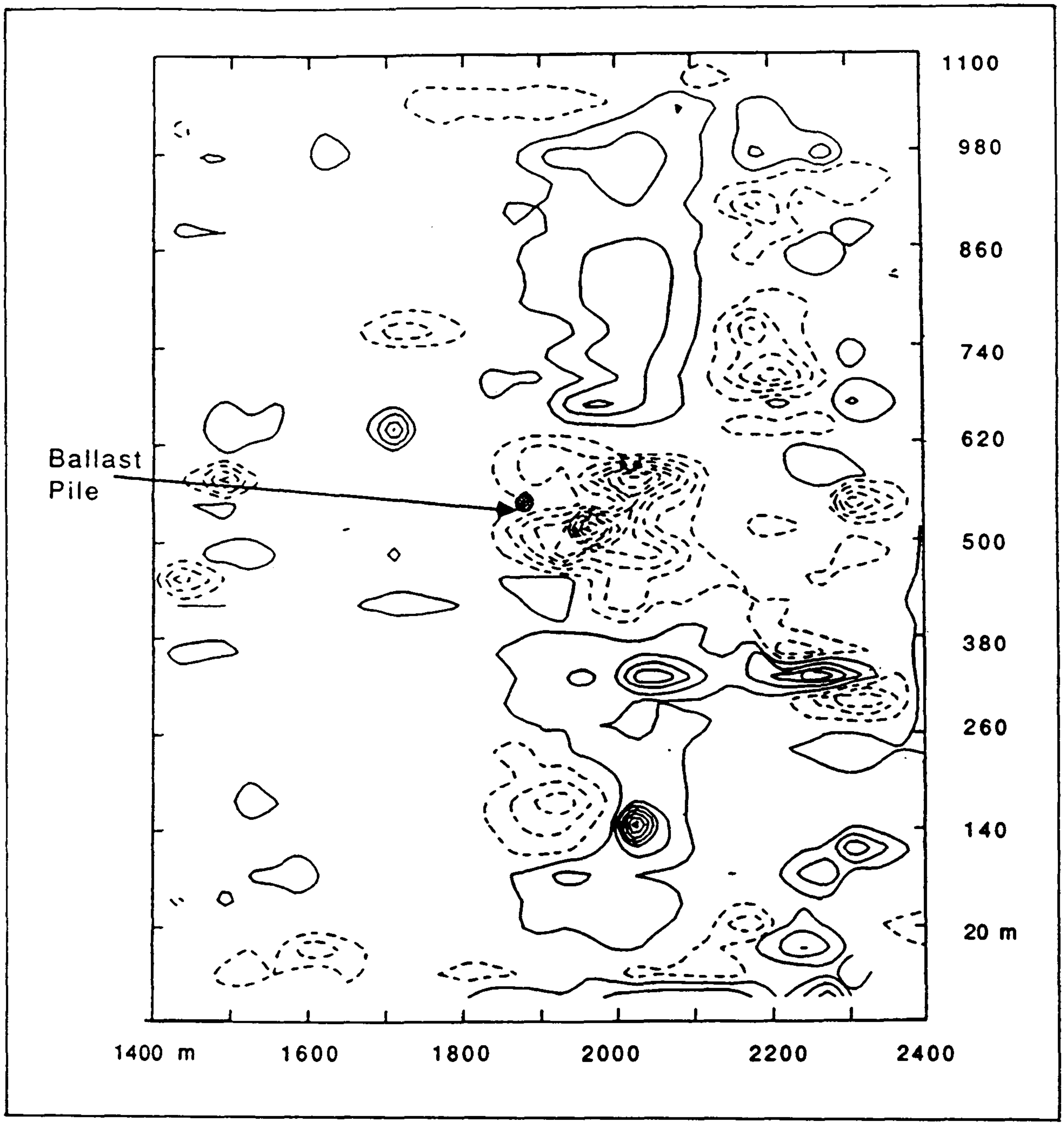


Figure 6-12. 100 meter lanespacing contour map of survey area from even 50 meter lanes.

Table 6-2
Side-scan Sonar Anomalies

Line #		Side-Scan Sonar Anomaly
01S		Nothing
02S		Nothing
03S		Nothing
04S		Nothing
05S		Nothing
06N		Nothing
07N		Nothing
08N		Nothing
09N		Nothing
10N	1	Ballast pile 35 m west of the line at (1919,575)
11S	1	Ballast pile 15 m east of the line at (1919,577)
	2	5 m west of the line at (1893,489)
12S	1	Ballast pile 70 m east of the line at (1917,570)
	2	20 m west of the line at (1832,530)
13S		Nothing
14S	1	5 m west of line at (1748,810) associated with dipole.
	2	32 m east of line at (1785,425)
	3	25 m west of line at (1729,180)
15S	1	Cluster of anomalies 25 m west at (1710,707 - 1685,707)
	2	37 m west of line at (1667,309)

	3	28 m east of line at (1732,499)
16N	1	25 m east of line at (1665,47)
	2	50 m west of line at (1600,437)
17N	1	25 m west of line at (1575,265)
18N	1	20 m west of line at (1536,613)
	2	25 m west of line at (1521,675)
	3	25 m west of line at (1530,719)
19N	1	Cluster 15-30 m east of line at (1520,265 - 1535,280)
	2	27 m west of line at (1473,781) associated with dipole
	3	30 m west of line at (1471,950)
20N	1	20 m west of line at (1431,300)
	2	24 m east of line at (1474,384)
	3	24 m east of line at (1473,476) with possible magnetic
32N	1	Ballast pile 73 m west of line at (1917,556)
	2	10 m west of line at (1982,632)
32S	1	Ballast pile 60 m to west of line at (1911,594)
	2	Directly under line at (1977,464) associated with dipole
34S	1	Ballast pile 47 m west of line at (1920,589)
	2	Directly under line at (1979,466) associated with dipole
36S	1	Ballast pile 27 m west of line at (1920,581)
37S	1	Ballast pile 16 m west of line at (1916,589)
38S	1	Ballast pile 12 m west of line at (1918,585)
39S	1	Ballast pile under line at (1917,580)
	2	Directly under line at (1920,396)
40N	1	Ballast pile under line at (1911,570)
	2	Directly under line at (1911,635)
41N	1	Ballast pile 12 m east of line at (1912,572)

42N	1	Ballast pile 28 m east of line at (1914,570)
	2	25 m east of line at (1913,605)
43N	1	Ballast pile 35 m east of line at (1914,572)
	2	Directly under line at (1883,675)
45N	1	Ballast pile 60 m east of line at (1915,575)
47N	1	Ballast pile 65 m east of line at (1910,577)
49N		Nothing

The side-scan sonar data is crucial for finding the ballast pile site when using 50 or 100 m lanespacing due to the lack of significant magnetic anomalies in the immediate area of the site. But at 100 m lanespacing the scan must cover 75 m on either side of its path to provide proper coverage overlap. At this range and in this water depth, only objects the size of a ballast pile are readily detected at the outer edge of coverage. Small objects could only be detected in the area 30 m either side of the line, which would leave a shadow zone in the middle of the lane where small objects would not be resolved. This is important as the object would probably not be detected by the magnetometer either. Thus it is important to have lanes of small enough size to allow sufficient overlap to detect the small but potentially significant objects. Smaller lanespacing also allows for the use of the 500 khz frequency, which has better resolution than the 100 khz frequency. The difference between 500 and 100 khz can be seen in Figures 6-13 & 6-14. The 100 khz output (Figure 6-13) is overwhelmed by false echos which mask any small anomalies present. The 500 khz record (Figure 6-14) is much cleaner and yields, on average, more identifiable anomalies than the 100 khz. In deeper water, the greater penetrating capability of the 100 khz frequency yields better records for larger areas than the 500 khz, but in the shallow water where this survey was conducted, 500 khz is the frequency recommended.

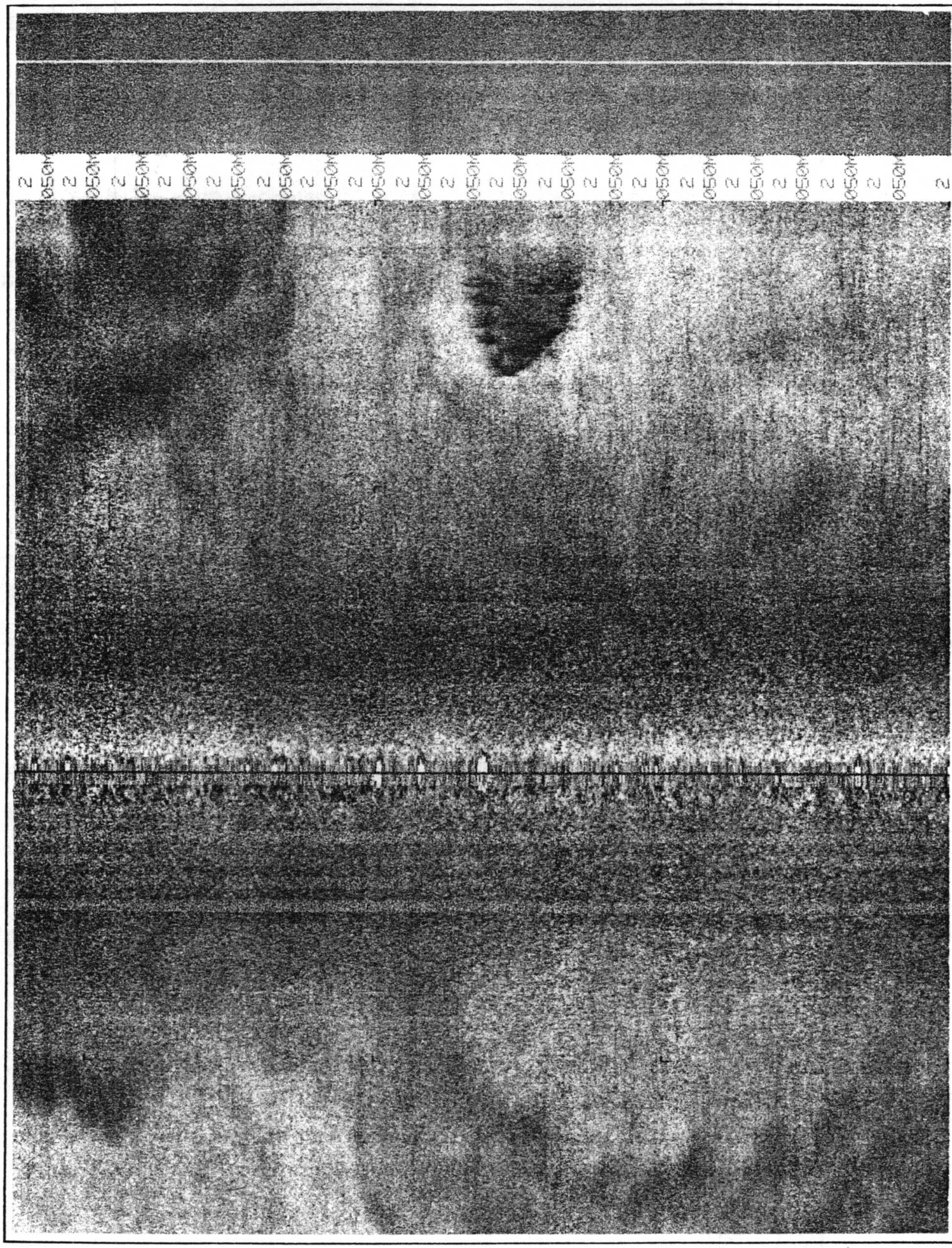


Figure 6-13. 500 khz side-scan sonar image of the ballast pile.

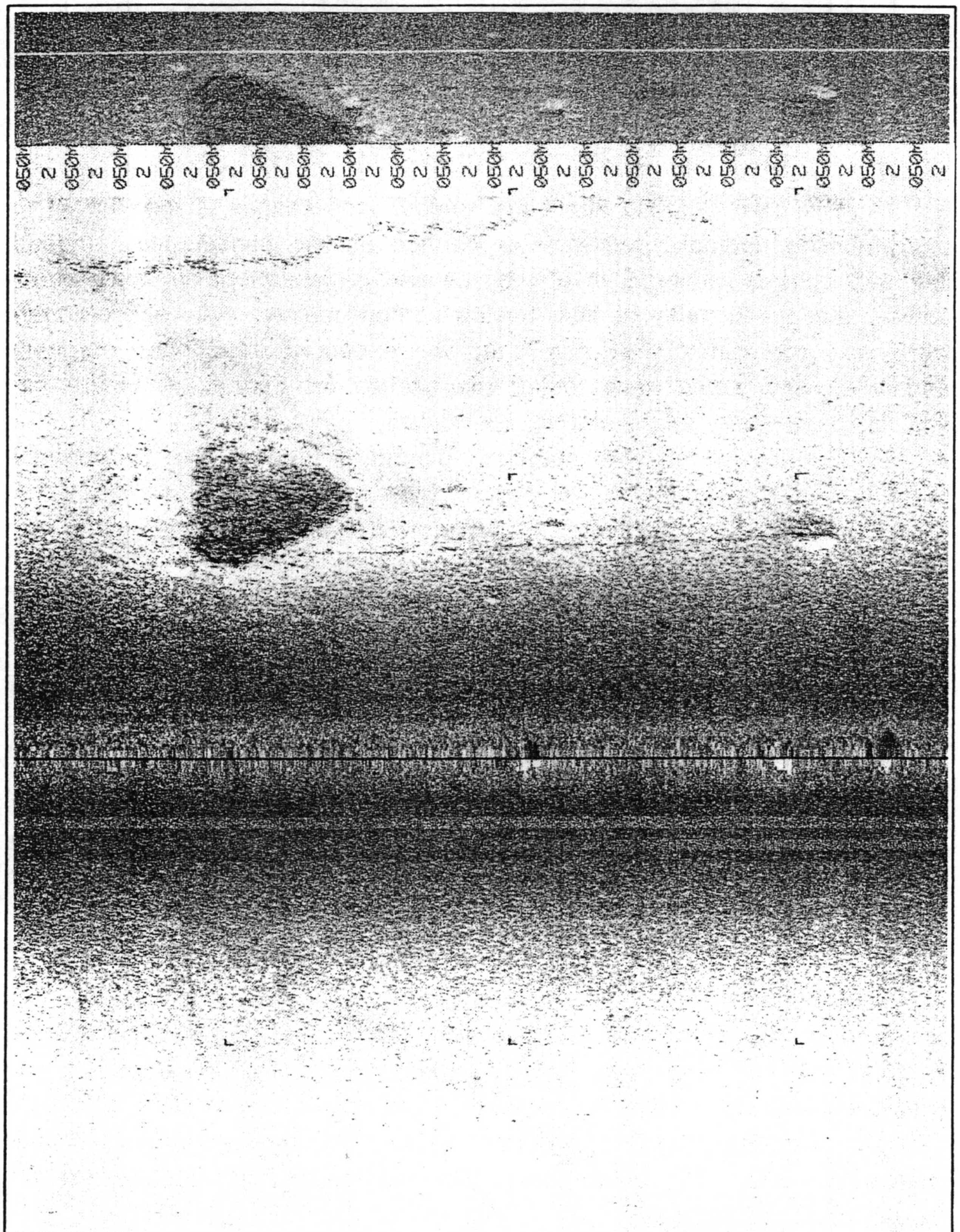


Figure 6-14. 100 khz side-scan sonar image of the ballast pile.

6.4 Discussion

6.4.1 Magnetic Anomaly Amplitude

What is most puzzling about the contour map images is the lack of an overwhelming anomaly from the six cannon on the ballast pile. Indeed, line 11S passed within 15 m of the site and registered an anomaly barely above, and questionably at that, the background noise. As we knew there were six iron cannon at this site, we expected significant magnetic anomalies and would have tested the towfish for instrument failure had this not been done before starting the survey.

To investigate this low magnetic signature, one of the two cannon retrieved for conservation was tested for its magnetic signature. The cannon was taken to the middle of an open field and a magnetometer was used to measure the magnetic signature of the cannon. The magnetics were measured both parallel and perpendicular to the length of the cannon. Using Equation 6-1 (Aitken 1974) with length 'A', width 'B', distance 'D' and magnetic value 'F' already known the weight 'W' that would produce such a magnetic value was calculated. For a cannon, 'A' = 1.88 m , 'B' = 0.31 m , 'F' = 110 gamma at 'D' = 1.56 m , the apparent weight is calculated as 70 kg, for a cannon weighing at least 700 kg, which is an order of magnitude low.

Equation 6.1
$$F = \frac{W \times 10}{D^3} \times \frac{A}{B}$$

At the same time, 72.5 kg of ballast rock were measured for their signature to make the same calculations. The rocks covered an area of roughly 0.4 m^2 and with their magnetic signature, correlated to an apparent weight of 0.7 kg.

On the basis of these "apparent" weights for the cannon and ballast rock some interesting calculations can be made with respect to the ballast pile site.

The six cannon are contained in an area roughly 9.35 m by 3.12 m (Figure 6-15). If these six cannon are considered one object of apparent weight 420 kg (6 x 70 kg), and a length over width ratio of 3.0 (9.35/3.12), then at a distance of 15 m it should have a magnetic value of 12.5 gamma. But for the same object with a length over width ratio of 0.33 (3.12/9.35), that value is 1.5 gamma. For the ballast pile the assumption is made that it is roughly 12.5 m by 12.5 m, and that 72.5 kg per 0.4 m^2 is applicable to the whole ballast pile. Then the ballast pile will have a total weight of 28,800 kg with an "apparent" weight of 278 kg. At a distance of 15 m this will have a calculated magnetic value of 2.5 gamma. Since the ballast pile is radially symmetric it will have the same calculated magnetic value for any orientation. Therefore, the cannon can give the same magnetic value as the ballast pile if approached from the proper angle. The cannon are aligned in a direction such that the length over width ratio is approximately 0.66 (Figure 6-15) and leads to the conclusion that due to the alignment of the cannon and their attendant low magnetic signature, they have a magnetic signature that is masked by that of the ballast pile. The broad baseline shift anomalies seen are certainly more indicative of geological rather than archaeological anomalies, with the dipoles appearing only when the magnetometer passes over the cannon. When the magnetometer passes directly over the ballast site it is at a distance of roughly 6 m. At that distance, the cannon have a calculated magnetic value of 50 gamma and the ballast pile 34 gamma. Lines 39S and 40N pass over the ballast pile with 39S having the larger anomaly because it passed over the side of the ballast pile containing the cannon, while 40N passed over the western edge, away from the cannon but still over the ballast.

6.4.2 Magnetic anomaly distribution

If this site is a shipwreck of a vessel that ran aground and was broken up and scattered along the shoreline, which has since retreated west to its present position, then the total area magnetic contour maps could represent where that previous shoreline was and where the debris was scattered along it to the southeast.

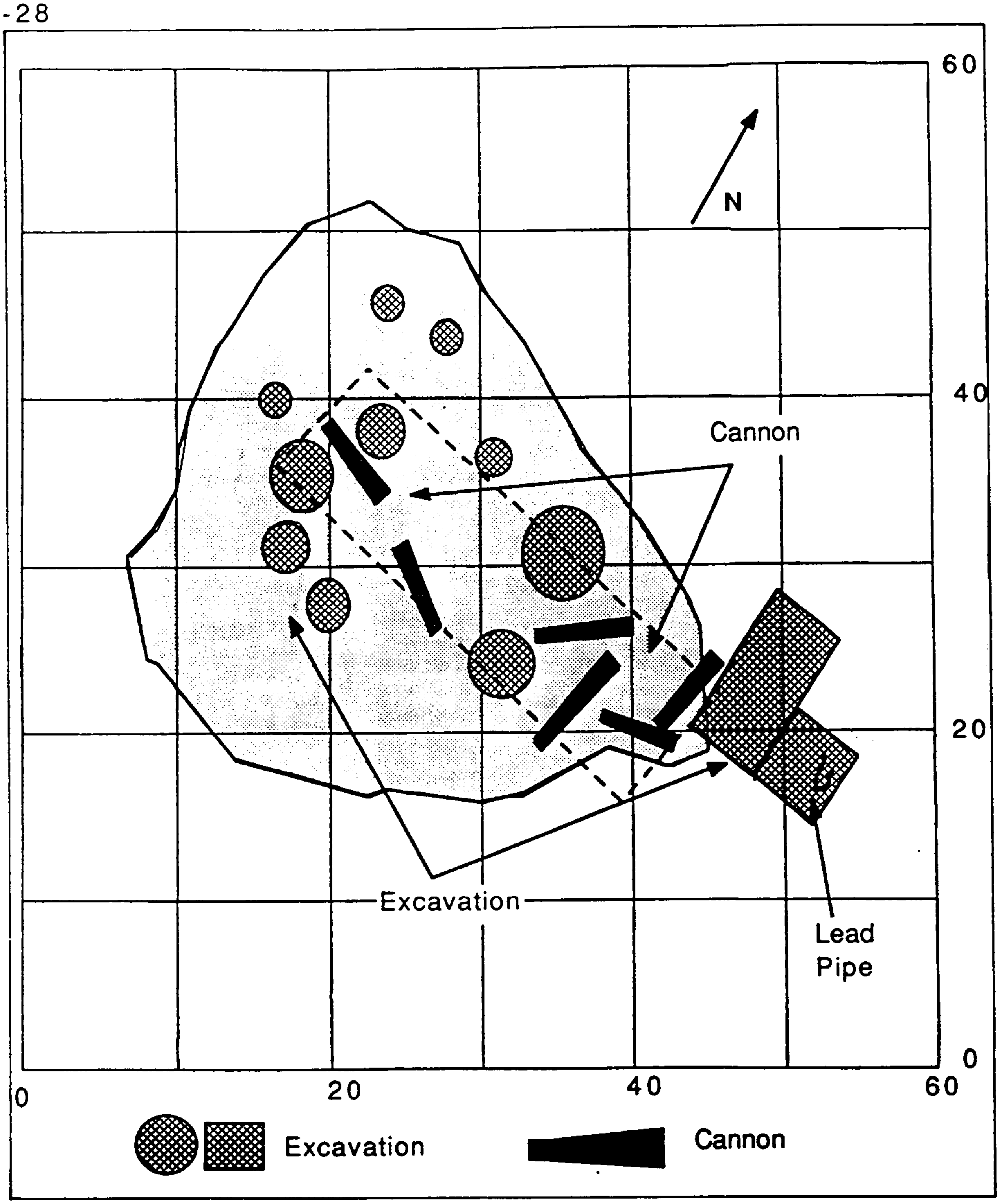


Figure 6-15. Site map showing outer limit of exposed ballast and distribution of cannon. Dotted line indicates limits of photomosaic shown in Figure 7-2. Grid is 3 meters (10 feet).

However, due to the absence of incidental artifacts expected with a shipwreck, our present assumption is that this is a site where a vessel ran aground and jettisoned its ballast to float free or pull itself free. If this is the case, then only the anomalies in the immediate vicinity of the ballast pile, seen on the subarea contour maps, would be associated with the site.

Either one of these theories can be further evaluated only by groundtruthing the anomalies outside the immediate vicinity of the ballast pile.

6.5 Conclusions

It is obvious that the smaller the lanespacing, the greater the detail made visible of any potentially significant archaeological site. Yet, even at 10 m lanespacing there is detail that is missed. The question is, what lanespacing provides the acceptable balance between the need for detail and the desire for speed and efficiency? It is clear from this study that 50 m is the maximum acceptable for the minimum of detail for magnetometer and side-scan sonar. Having done several lease block surveys at 50 m lanespacing, it is readily conceded that 50 m is the minimum lanespacing acceptable for maximum speed and efficiency. With competent professionals and the proper equipment, a survey with 50 m lanespacing, using a magnetometer and side-scan sonar, can detect the majority of the larger archaeologically significant sites if they exhibit either several large magnetic anomalies and/or any significant features exposed above the bottom sediments. The side-scan sonar is a must for the survey as it can detect anomalies that may not, at first pass, display a magnetic signature, but which upon closer examination are indeed magnetic as our experience with this site has shown (see Section 6.4.1). The closer examination (e.g. groundtruthing) of anomalies that are not clearly modern is unavoidably necessary. Groundtruthing and putting a hand on the anomalies is the only way of knowing what possible historic significance the anomalies may have.

7.0 ARCHAEOLOGICAL STUDY RESULTS

7.1 Site Features, Artifacts and Interpretation of the Chandeleur Islands Site

The archaeological remains of many historic shipwrecks are typically composed of a variety of materials which may include wood and wooden hull remains, rope, fiber, ballast, tar and/or pitch, ceramics, coins, glass, galley bricks, floral and faunal food items, a profusion of iron and/or copper fasteners, bar stock, chain, ship's hardware and rigging, anchors, tools, weaponry, copper or lead sheathing, leather, cargo remains and their containers, personal effects belonging to sailors, and on occasion, navigation instruments. The artifact assemblage from the Chandeleur Islands Site is atypical in comparison with the "ideal" historic shipwreck remains described above, as defined by both the type and quantity of archaeological materials recovered. On the basis of their analysis, the authors propose a scenario in which the site formed due to the grounding of a vessel on an inshore sand bar during the last quarter of the 18th century. Ballast rock and cannon were off-loaded to lighten the vessel, thereby permitting its departure. Support for this theory is based on the absence of any preserved hull remains, the paucity of characteristic shipwreck artifacts, the physical condition of the six cast iron cannon which suggests that they were dysfunctional and stored below decks as ballast, the stratigraphy of the ballast pile which is clearly reversed in comparison with that of a typical shipwreck and the magnetic signatures of anomalies in the vicinity of the ballast pile. In addition, the authors suggest that one or several of the magnetic and acoustic anomalies mentioned above may reflect the signatures of drag anchors employed by the vessel to slow its rate of drift toward the islands. This hypothesis is supported by the recorded intensity of the magnetic anomalies, their orientation in relation to the ballast pile and the islands and their proximity to the site. An alternate scenario proposed by the authors is that the site formed due to the wrecking of a vessel on an inshore sand bar. Support for this theory is somewhat ambiguous and relies primarily on the groundtruthing and identification of the aforementioned magnetic and acoustic anomalies recorded in the vicinity of the ballast pile (see Section 6.2.1).

The artifacts recovered from the site are listed in the artifact catalogue presented in Table 7-1. The assemblage is composed of ballast rock including a sandstone grindstone fragment, six low-fired red clay tile fragments, a lead patch, a possible lead pump tube, four ceramics, fragments of an iron encrustation and six cast iron cannon. A description of the stratigraphy of the ballast pile precedes the discussion of the artifacts.

Table 7-1
Artifact Catalogue

IEC89001	ballast rock
002	" "
003	" "
004	" "
005	" "
006	" "
007	" "
008	" "
009	" "
010	" "
011	" "
012	" "
013	" "
014	" "
015	" "
016	" "
017	" "
018	" "
019	" "
020	" "
021	grindstone fragment
022	ballast rock
023	red clay tile
024	" " "
025	" " "

026	" " "
027	" " "
028	" " "
029	lead patch
030	lead pipe
031	" " "
032	iron concretion
033	" "
034	" "
035	" "
036	" "
037	" "
038	" "
039	" "
040	" "
041	" "
042	" "
043	" "
044	ceramic, green lead-glazed earthenware plate
045	ceramic, green lead-glazed earthenware base fragment
046	ceramic, gray lead-glazed stoneware
047	wood, iron mineralized
048	" " "
049	iron concretion
050	" "

7.2 Ballast Pile

Ballast rock piles are probably the most enduring of all the possible archaeological remains of shipwrecks. They are often identified by their characteristic ellipsoid or "ship-like" shape. Analysis of their dimensions can yield estimates of the size and gross tonnage of the vessel. In some cases, geological analysis of their constituent stones can identify the vessel's port-of-origin or ports-of-call if ballast stones are found which are diagnostic to a specific region. The ballast stones which make up this site are primarily a grey igneous rock, however, some metamorphic and sedimentary examples were recovered.

The stratigraphy of the ballast pile is probably the best archaeological evidence in support of the vessel grounding theory. The basis for this hypothesis is that the ballast rocks are deposited in distinct strata in reverse of what one normally encounters in the pile of a rock ballasted shipwreck. A stratigraphic cross-section of the ballast pile is represented in Figure 7-1. The site is formed of five distinct strata. The upper three strata are composed of ballast rock in which the average particle size per stratum decreases from top to bottom. In other words, the largest boulders are deposited on the top, followed by large cobbles, small cobbles, shell hash and, finally, bottom sand. The upper stratum, upon which sit the six cast iron cannon, consists of boulders 30-60 cm in diameter with some boulders greater than 60 cm (Figure 7-2). Beneath the boulders is a stratum of large cobbles (20-30 cm). The next stratum is composed of small cobbles 10-20 cm in diameter. These three strata are deposited over a layer of shell hash approximately 3-4 cm thick. Beneath the shell hash is sand bottom.

At the time of the survey the dimensions of the ballast pile were measured at approximately 13.5 x 10 x 1.1 m. Sand had accumulated over the sides of the pile up to the boulder and large cobble strata. Due to the large volume of sand transport resulting from longshore drift and high energy storm events along the barrier islands the amount of the ballast pile buried by sand regularly fluctuates. Consequently, so does the visible extent of the site. This observation was confirmed by Mr. Kenny Barhanovich, captain of the MISS HOSPITALITY, and Mr. Derrick Groves, who located and explored the site in the spring of 1988. They reported that on their initial dive, the highest elevation of the ballast pile extended to at least 1 m above the sand bottom. During the survey in May 1989, the ballast pile was covered by sand so that only 0.45 m was visible above the bottom. The actual maximum cross sectional depth of 1.1 m was measured within an excavation test trench in the center of the ballast pile.

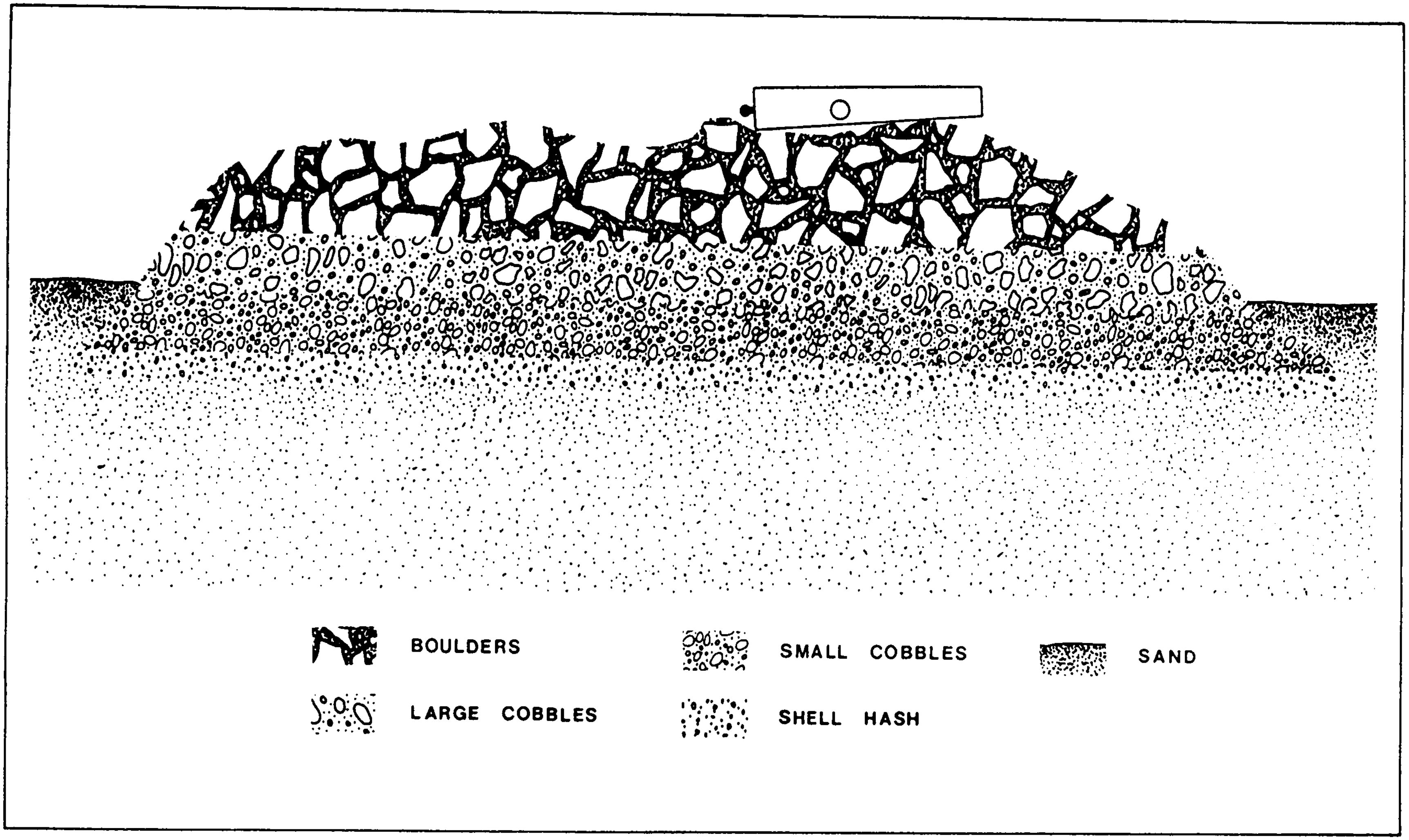


Figure 7-1. Stratigraphic cross-section of the ballast pile.

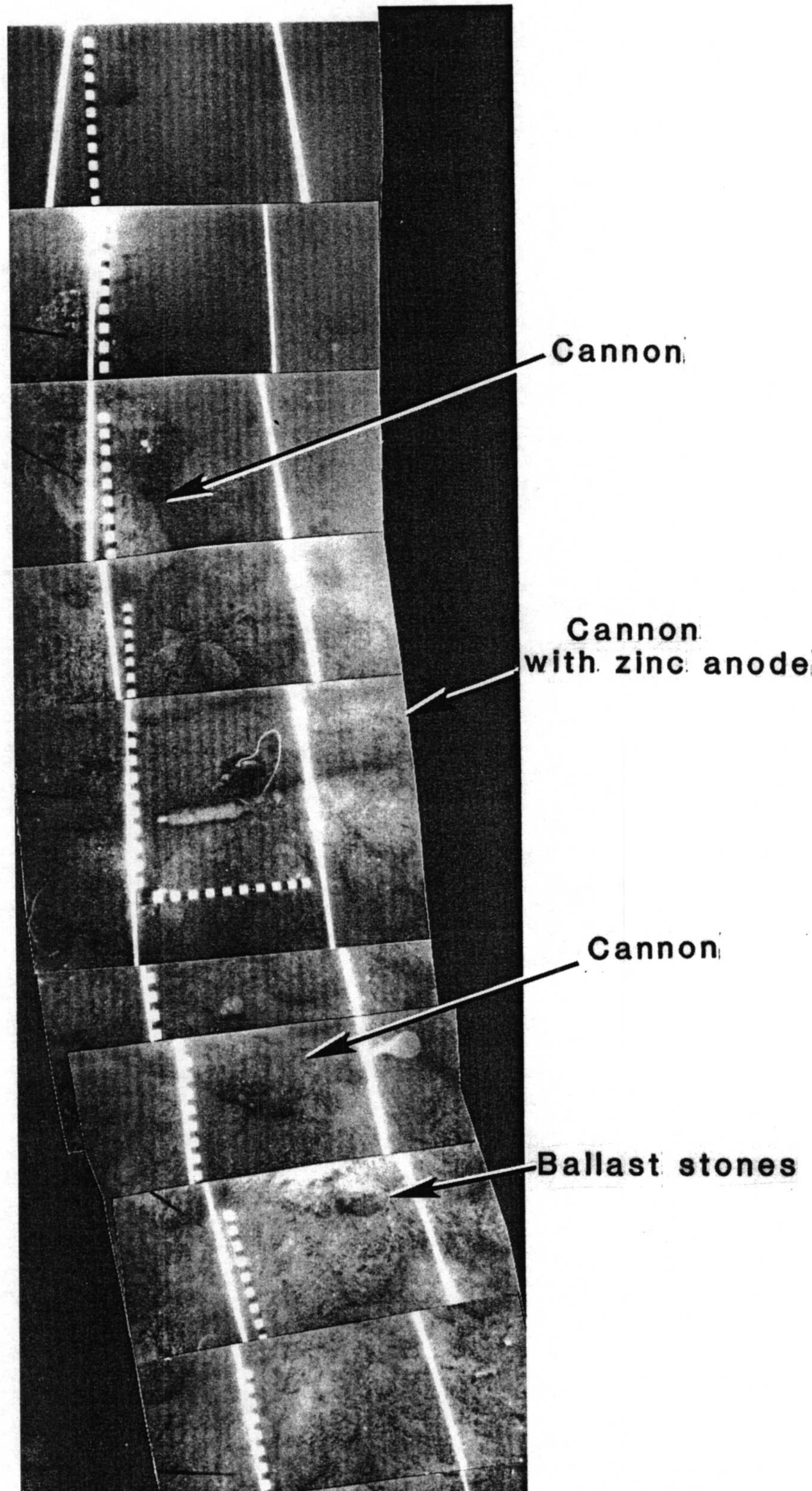


Figure 7-2. Partial photomosaic of the upper stratum of the ballast pile showing three cannon. Scale rods are 60 cm in length

To prove conclusively that this site represented the remains of a vessel grounding rather than a shipwreck, it was crucial to ascertain that there were no wooden hull remains of the vessel anywhere within the stratigraphy of the ballast pile. This necessitated the excavation of test trenches over the entire extent of the site down to the level of the bottom sand. Twelve test trenches were excavated and their location is shown in Figure 7-3. In all cases, the stratigraphy within the trenches followed that presented in Figure 7-1 (boulders, large cobbles, small cobbles, shell hash and bottom sand) and no evidence of any wood construction features was encountered. If this was the site of a shipwreck, one would expect to find the wooden remains of the vessel stratigraphically represented somewhere near the bottom so that the generalized cross-section from bottom to top would be as follows: bottom sand, shell hash, wooden vessel construction features, boulders, large cobbles, and small cobbles.

7.3 Analysis of the Ceramics

The ceramic assemblage consists of only four shards. Two are fragments of green lead-glazed coarse earthenware (IEC89044; IEC89045) and one is a fragment of a poorly made gray salt-glazed stoneware (IEC89046). The fourth shard was a fragment of brown bellarmine which was lost on site.

The analysis of the coarse earthenware is based on the Fort Michilimackinac typology of 18th century ceramics by Miller and Stone (1970). Following their typology, two ceramic fragments are classified into Class A Earthenware, Group III Coarse Earthenware and Type D Green Glazed Earthenware. The ceramic type is described as "variants of low fired earthenware covered with a green lead-glaze" and is divided into light-green and dark-green on the basis of color. Light-to-medium green glazing may appear on one or both sides. The paste ranges in color from brown-red through buff to tan-grey. The craftsmanship is generally crude and most of the shards appear to have come from chamber pots, jars, and bowls.

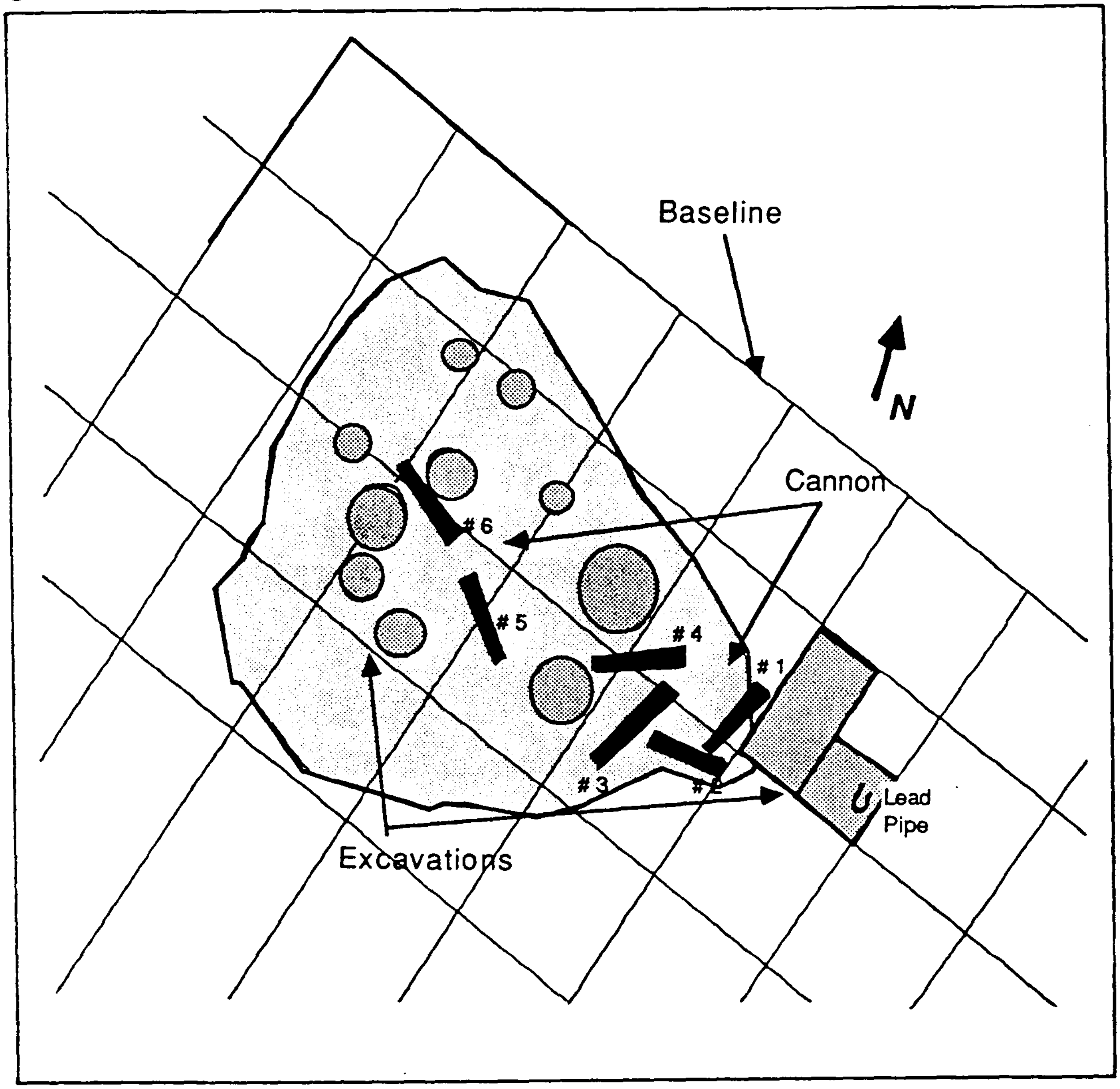


Figure 7-3. Site map showing the outer limit of the ballast pile, the location of the cannon and the test trench excavations. Grid is 3 meters (10 feet).

7.3.1 Green Lead-Glazed Coarse Earthenware Plate (IEC89044)

IEC89044 is a section of a shallow, wheel thrown plate with a slightly convex base (Figure 7-4a), and a rim diameter of approximately 24 cm. The interior is covered with a green lead-glaze (Munsell 2.5 Y 6/6 olive yellow) spotted with dark green splashes (Munsell 5 Y 5/4, olive). Both the interior and exterior of the plate is covered with a cream colored slip (Munsell 10 YR 8/3, very pale brown) and the exterior exhibits accidental splashes of the green interior glaze, but is otherwise unglazed. The body color is light gray (Munsell 2.5 Y 7/0).

A similar form found in Miller & Stone (1970) is reproduced in Figure 7-4b. It is a section of a flat based, wheel thrown plate covered with a green lead-glaze with brown splashes. Miller & Stone identify this plate as French or French Canadian and date it to the first half of the 18th century. The most noteworthy attribute of this example is the extremely close resemblance of its section drawing with that of IEC89044.

Another example of this ceramic type was recovered from the Fort Desha, Arkansas Post dated ca. 1735-1750 (McClurkan 1971). It is a rim shard from a bowl with a light green lead glaze over a white slip covering the interior. The exterior is unglazed.

Noel Hume (Miller & Stone 1970) has identified samples of the green lead-glazed ware from Williamsburg, Virginia, especially the type with both sides glazed, as being of English derivation on the basis of context. This style of glazing is seen also in indigenous colonial and French coarse earthenware assemblages from the Fortress of Louisbourg (Marwitt 1966). According to Miller & Stone, the provenance of green lead-glazed earthenwares is not well defined and may reflect an English, French or colonial American association depending on archaeological context. At Fort Michilimackinac the green lead-glazed coarse earthenwares were identified as French or French Canadian and were dated ca. 1740-1760 on the basis of feature associations. Regardless of the provenance, green lead-glazed coarse earthenware cannot be dated more exactly than from the first half to the middle of the 18th century.

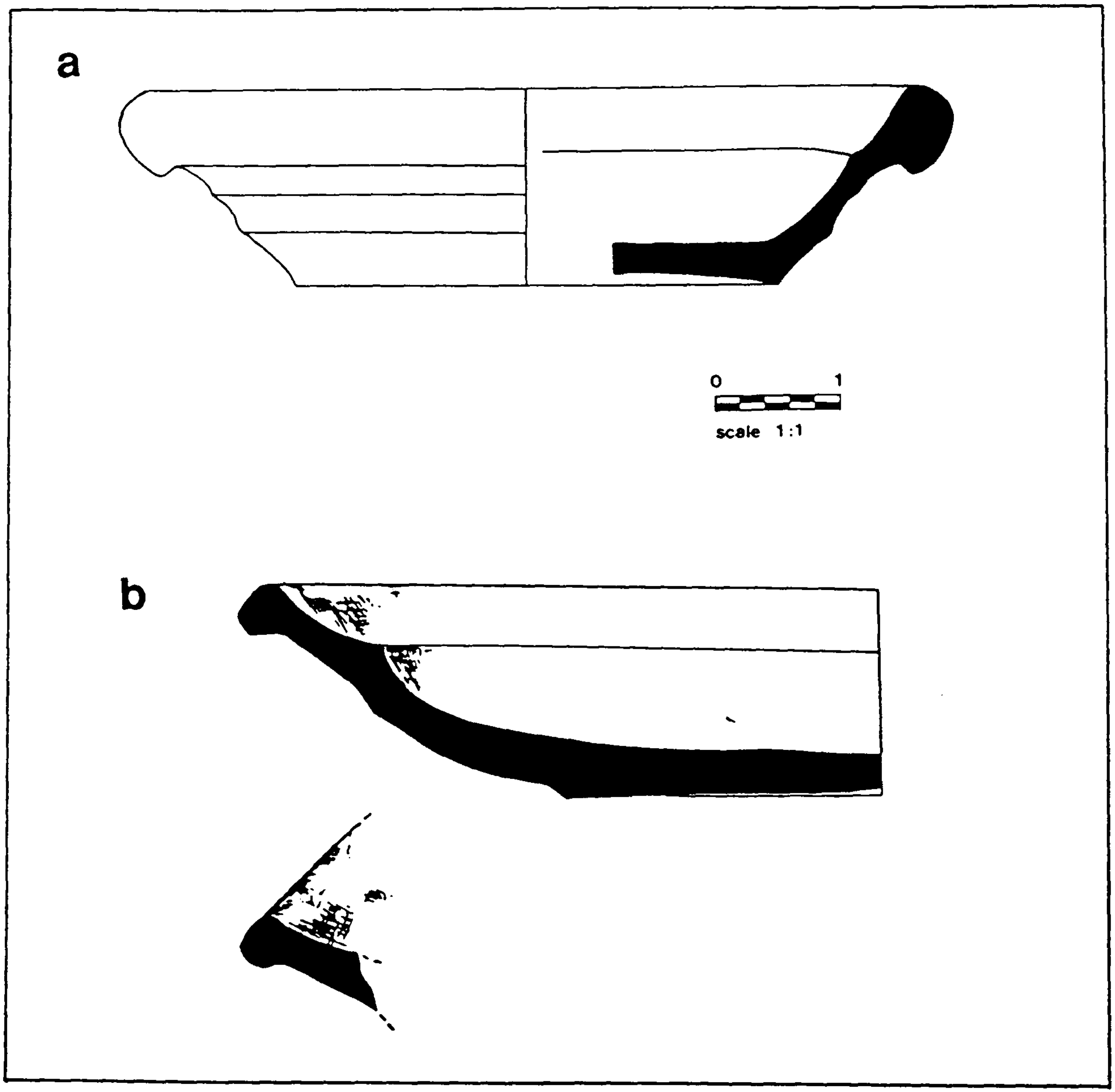


Figure 7-4. (a) Green lead-glazed coarse earthenware plate fragment, (IEC89044); (b) Coarse earthenware plate (from Miller & Stone 1970).

7.3.2 Green Lead-Glazed Coarse Earthenware Base Fragment (IEC89045)

IEC89045 is the base fragment of a thick-walled storage jar or chamber pot (Figure 7-5). The interior glaze is composed of a mixture of dark green (Munsell 5 Y 4/2, olive gray) and light green (Munsell 5 Y 6/5. pale olive; 5 Y 7/6, yellow) splashes over a slightly pinkish slip (Munsell 5 YR 7/6, reddish yellow). The exterior is unglazed and the body is gray (Munsell 10 YR 5/1). The shard appears to retain the remnant of a foot but because the fragment is small it is difficult to be certain. For the same reason, it is impossible to identify the form. However, on the basis of the thickness of the base and wall, the crudeness of manufacture and the sharp angle at which the wall rises, the form is likely to be either a chamber pot or large storage jar. Following the discussion above, the provenance may be French, English or colonial American and the type dates to the first half of the 18th century.

7.3.3 Gray Salt-Glazed Stoneware (IEC89046)

IEC89046 is a very small fragment of stoneware of unidentifiable form or date. The glaze is light gray (Munsell 5 Y 7/1) and the body is white (Munsell 10 YR 8/1).

7.4 Lead Patch (IEC89029)

IEC89029 is an almost square (19.8 cm x 17.8 cm x 0.31 cm) sheet lead patch with two round fastener holes. As presented in the section drawing in Figure 7-6, the fasteners were driven through the top of a rounded ridge which flattens out and then rises again as if to fit up against an edge. It is evident that the patch has retained the shape of the object to which it was attached. Although no remains of this object were preserved, it was most probably constructed of wood. Sheet lead was used for a variety of protective applications on sailing vessels including hull sheathing, patches for wooden containers, barrels, casks, or hogsheads

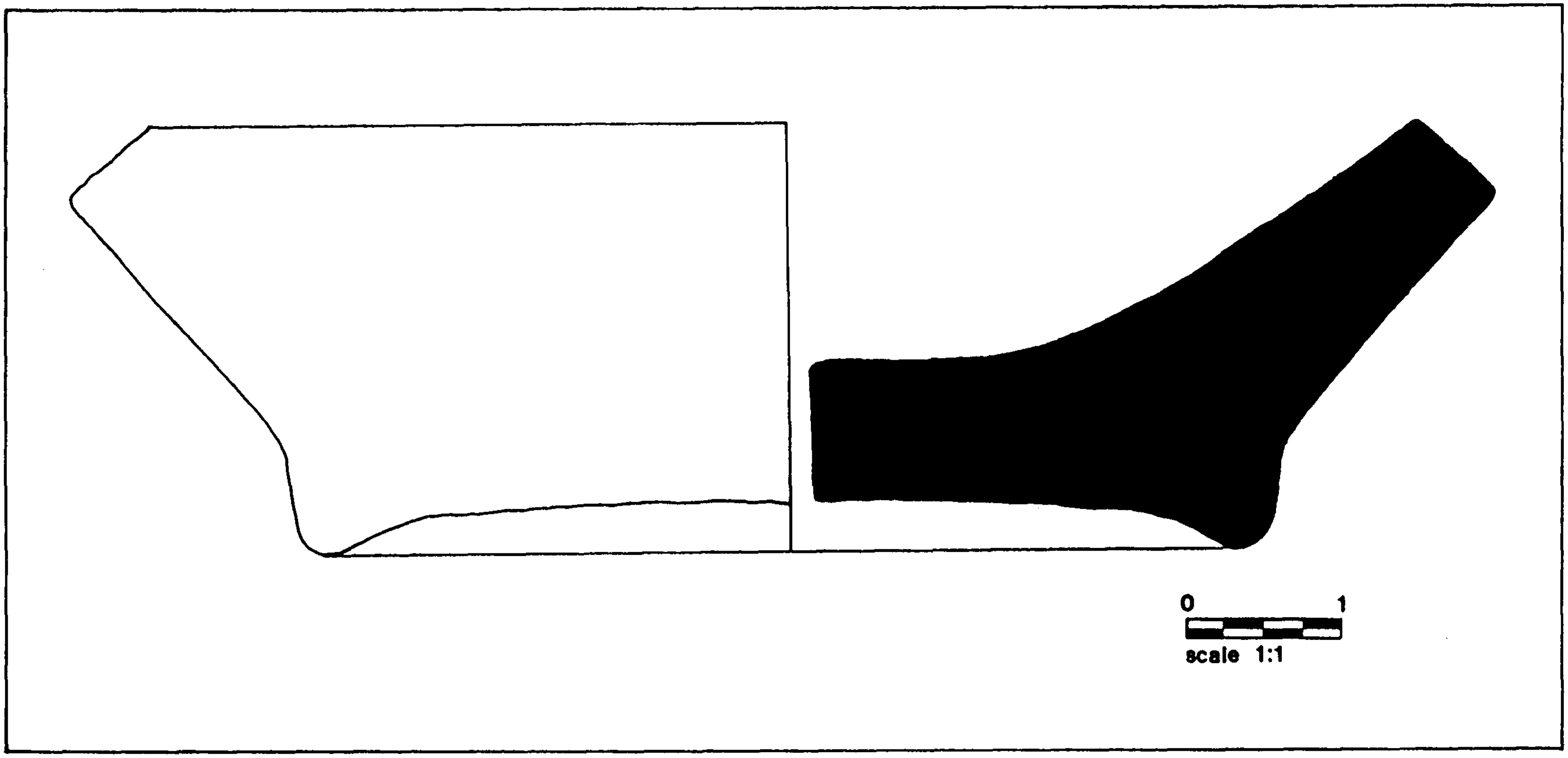


Figure 7-5. Green lead-glazed coarse earthenware base fragment, (IEC89045).

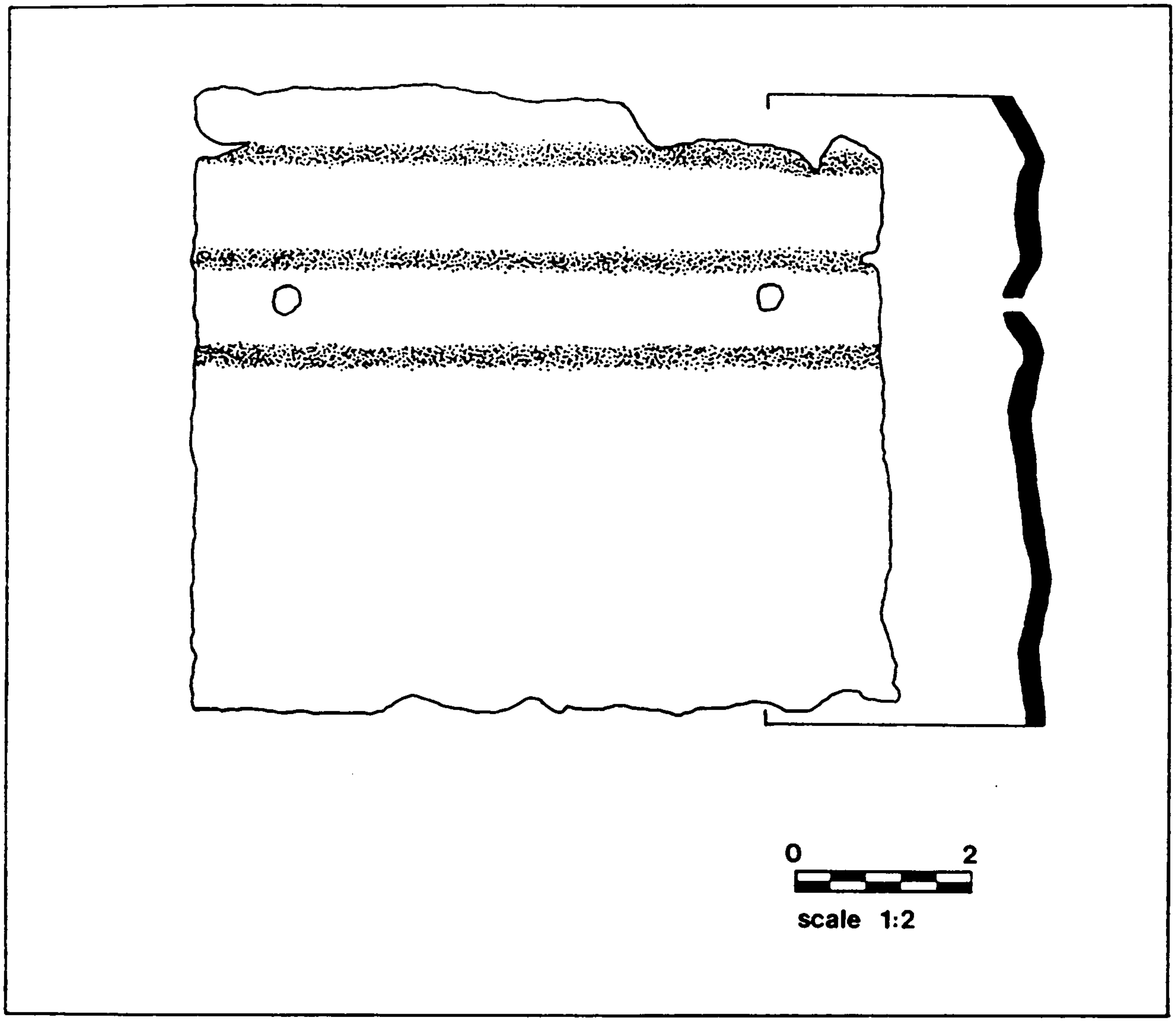


Figure 7-6. Sheet Patch, (IEC89029).

(Kerry Shackleford, personal communication 1988), temporary hull patches (Arnold & Weddle 1978) or any repair that required a measure of strength with an easily worked, malleable material. Boteler (1634) mentions the use of sheet lead for leaks; however, because the lead sheet tended to crack due to the constant motion of the ship and flexing of the hull, a double layer of leather or canvas backed with oakum was preferred (Treatise 1793).

Due to the lack of any diagnostic features and the ubiquitous use of sheet lead on sailing vessels, it is impossible to specifically date this artifact.

7.5 Lead Tube (IEC89031)

The remains of a possible lead pump tube was recovered from the sand immediately southeast of the ballast pile in a test trench excavated to ascertain the areal extent of the ballast rocks. The lead tube was retrieved in two twisted pieces and is shown in Figure 7-7a. A complete discussion of the history and technological development of ships' pumps is given by Oertling (1984), on which is based much of the discussion below.

The first use of lead in the manufacture of ship's pump parts may be dated to as early as the 16th century, an example of which is the lead piston valve from the Molasses Reef Wreck in the Turks & Caicos Islands, British West Indies (BWI). Increased use of metals in the fabrication of pump parts continued well into the 19th century. An example is a section of large diameter (18.8 cm) lead tubing salvaged from the CSS GEORGIA (1864). Eighteenth century examples of ships' pumps with lead parts include the SAN JOSE (1733), three sections of lead pumps recovered from the York River at Yorktown, Virginia dated to the Battle of Yorktown, 1781, a section of lead tube from the Yorktown Shipwreck (44YO88) found within the pumpbox housing also dated to 1781 and a box-like lead sieve and a sheet lead sieve from the MACHAULT (1760). In addition to pump parts, lead tubing was used in ships for scuppers and heads, particularly for lining head trunking or drainage sluices from seats-of-ease and for soil-pipes or pissdale pipes which ran to the water line (Simmons 1985).

It is possible that the tube recovered from this site is related to shipboard sanitary facilities.

The simplest method for fabricating a tube was to roll a sheet of lead over on itself edge to edge and solder the edges together. The lead sleeves fitted around the tube were produced in this fashion and the top, bottom and center seams were soldered together. Diderot (1966) described an alternate method of casting lead pipe which developed in the 18th century. By this method, lead pipe was mold cast in sections and then drawn out of the mold leaving a few inches of the finished tube section in the mold. A new section was then cast which joined the first enabling the production of cast tubes of any length and of consistent diameter and wall thickness. Lead tubes cast by this process exhibited mold marks on opposite sides running the length of the tube and at intervals where sections were cast together. The lead tube recovered from the site was fabricated by this method. There are parallel, slightly raised mold marks running the length of the tube. The mold marks which formed where sections were cast together represent the weakest part of the tube and these are covered by the reinforcing sleeves. Figure 7-8 presents a cutaway cross section of the tube and a reinforcing sleeve. The preserved length of the tube is 264 cm, the average interior diameter is 4.1 cm and the tube wall averages 0.87 cm, making the average tube outer diameter 5.84 cm. The reinforcing sleeves are 10 cm in length, and average 0.45 cm in width, making the total average outer diameter of the sleeve and tube 6.74 cm. The average cross-sectional diameter of the tube wall and sleeve is 1.32 cm. The average distance between sleeves is 43 cm.

The lower 15 cm of the tube (IEC89031) is pierced with numerous holes 0.31 cm in diameter and may have functioned as a built-in sieve. Specialized sieves fabricated from copper or lead sheet were fitted over the lower end of a pump tube to prevent the valves from clogging with debris. The sieve holes were formed by piercing the sheet metal with a hot poker or gouge. Scribed lines for fitting the sieve to the tube are often preserved on the interior face of the sieve plate as are small nail holes for attaching the sieve to the tube. Examples of 18th

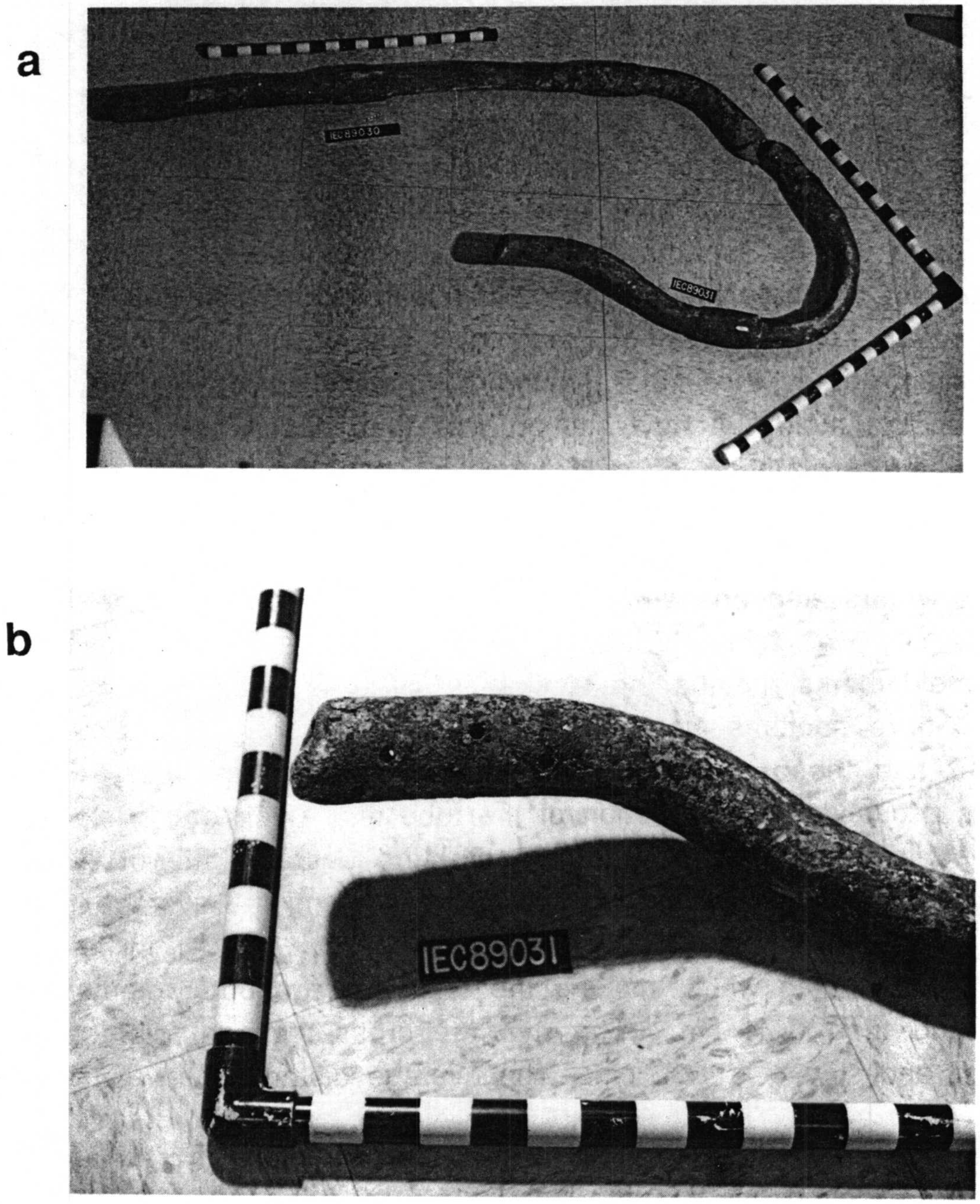


Figure 7-7. (a) Cast lead pump tube, (IEC89030/IEC89031); (b) lower end of the pump tube showing the incorporated sieve design. Scale length is 60 cm.

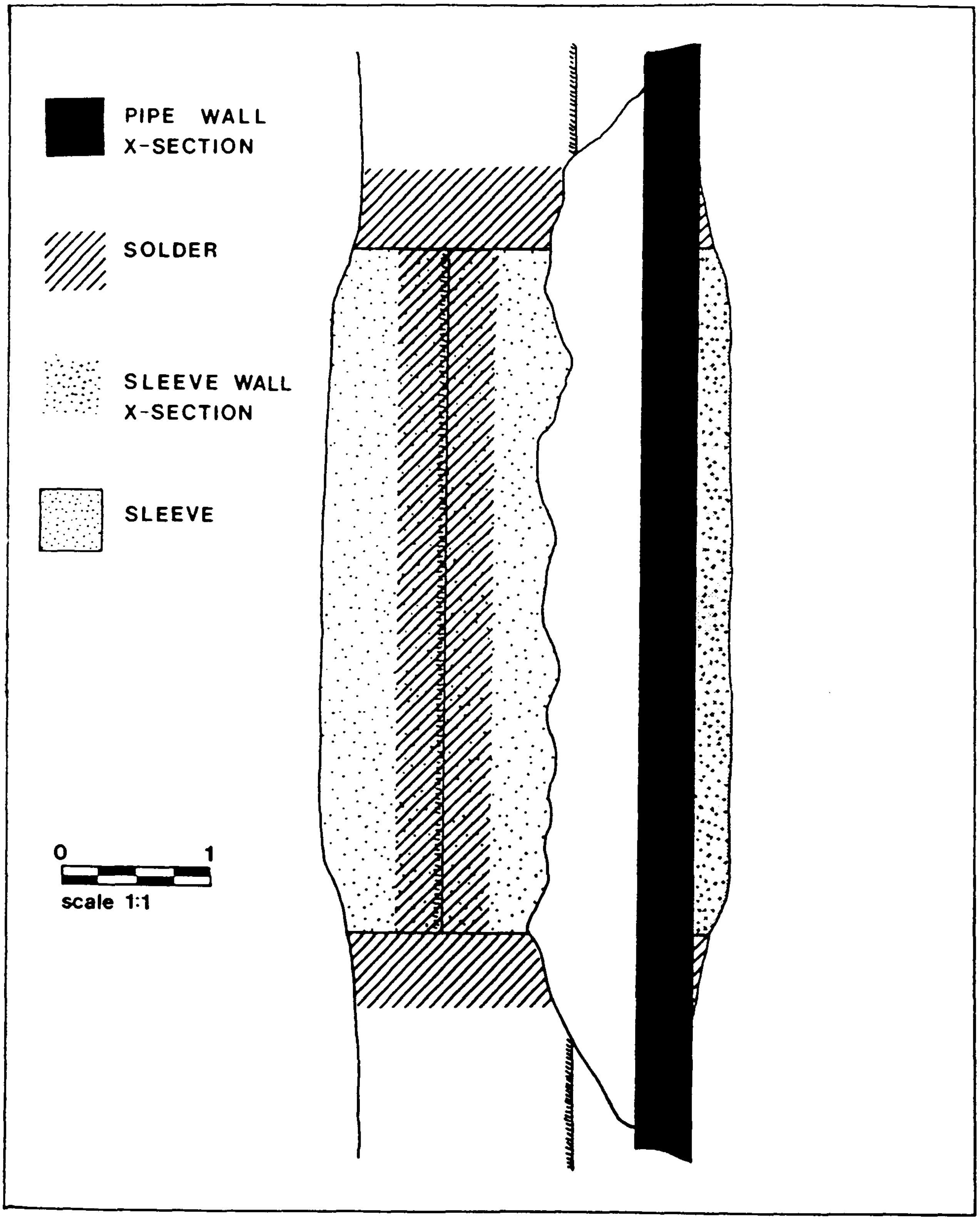


Figure 7-8. Cutaway section of the lead pipe and sleeve.

century sieves include two from the MACHAULT (1760) and three from the EL NUEVO CONSTANTE which wrecked on the Louisiana coast in 1766 (Pearson 1981).

The pump tube from the Chandeleur Islands site is unique in that its sieve was included as an integral part of the lower-most cast section of the tube (Figure 7-7b). The holes were pierced or drilled completely through the tube diameter and perpendicular to its length so that each hole has a parallel mate on the opposite wall. This sieve and pump tube combination design represents the first of its kind recovered from an 18th century underwater archaeological context.

The main problem in identifying IEC89030/IEC89031 as a bilge pump tube is its small interior diameter of 4.1 cm in comparison with the interior diameters of known pumps recovered from 18th century shipwrecks. For example, the bore diameter of the French Royal Pump was 16.3 cm for the upper tube and 12.2 cm for the lower tube. The bore diameter of the pump tubes in the L'IMPATIENTE (1796) was 17 cm. The Louisberg wreck (mid-18th century) was 16.5 cm and the Yorktown shipwreck 44YO88 (1781) was 12.7 cm (Oertling 1984). The interior diameters of these pumps are all three to four times greater than that of the tube recovered from the site. An alternative application of pumps on 18th and 19th century warships were the wash pumps used for washing and fire fighting. In this configuration, clean sea water was fed through lead pipes, which pierced the sides of the vessel, into the well or a cistern from which water was pumped. The bore diameter of the pump tube in this application would have been substantially smaller.

7.6 The Swedish Cast Iron Cannon

Six cast iron cannon were found on the site. Two, a four-pounder and a three-pounder, were recovered and brought back to Texas A&M University for conservation (Figure 7-9a). Of the six cannon, three bear similar fabrication marks on their right trunnions. These gunfounder marks consist of three capital letters, IEC, used by the Swede, Johan Benjamin Jesper Ehrencreutz of the Ehrendals Bruk (foundry) between 1771 and

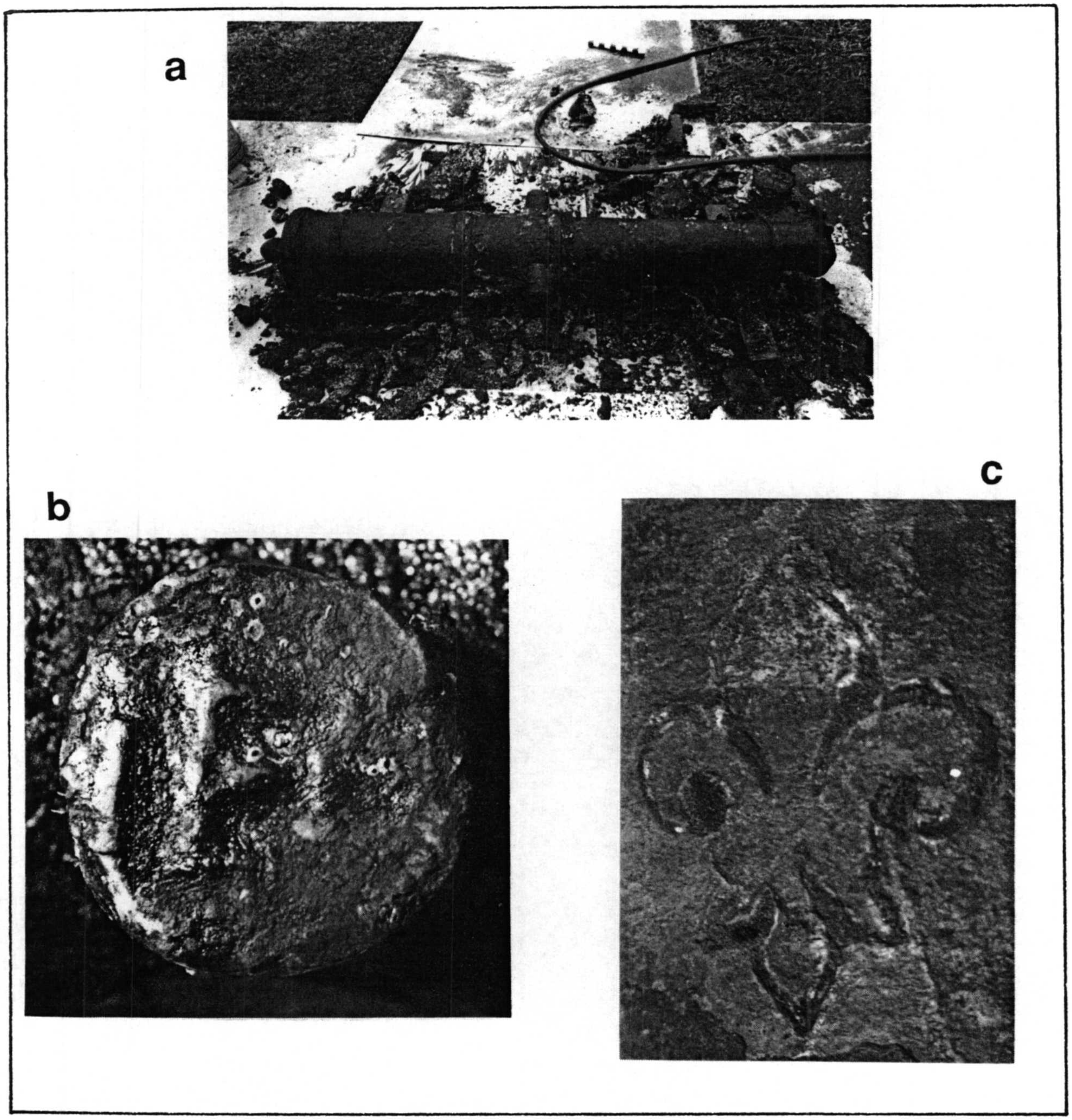


Figure 7-9. (a) Swedish-made four-pound cannon after removal of the encrustation; (b) Swedish gunfounders mark, IEC, cast into the right trunnion of the cannon; (c) Fleur-de-lis insignia cast into the top of the Swedish-made cast iron three-pound cannon.

1784 (Figure 7-9b). In addition, the two cannon, presently under conservation treatment, have three fleur-de-lis apiece inscribed or struck into the top side of the guns (Figure 7-9c). A similar pattern of three fleur-de-lis cast into the top of a 12-livre cannon recovered from the MACHAULT (1766) is shown in Figure 7-10. They are located at the muzzle, between the trunnions and at the touchhole. The appearance of the fleur-de-lis on the cannon strongly support an interpretation for French origin of the vessel responsible for the deposition of the ballast pile. A more in-depth description of the physical attributes of the cannon may be found in the conservation section of this volume (Section 9).

For the purposes of this discussion it is important to note that five of the six cannon showed evidence of use related damage which occurred prior to their deposition on the ballast pile. Damage to these guns included burst muzzles, bores and cascabels, broken trunnions and longitudinal cracks along the muzzles. Although evidence of physical damage on the sixth cannon is uncertain, the we expect that it too was damaged in some fashion. On the basis of this information, the authors speculate that all the cannon found on this site were dysfunctional and were stored below decks as ballast. At the time of the grounding, dating no earlier than 1771, these cannon were thrown overboard to lighten the load of the vessel enabling it to move off the sand bar.

7.7 Red Clay Tile Fragments (IEC89023-IEC89028)

Six fragments of thin, flat, low fired, red clay tiles were recovered from the site. Five of the tiles were found by Barhanovich and Groves on their initial exploratory dives. All the tiles are partial and composed of like material with the exception of IEC89025 which is made of a more finely levigated clay and is flat on both faces. The other five tiles are flat to slightly concave on the bottom side and are impressed with three ridges and four troughs on the top side (Figure 7-11a). The grit ranges in size from 0.31 cm (1/8") to 1.3 cm (1/2"). The tiles are roughly the same color, width and thickness. Their length varies with the size of the

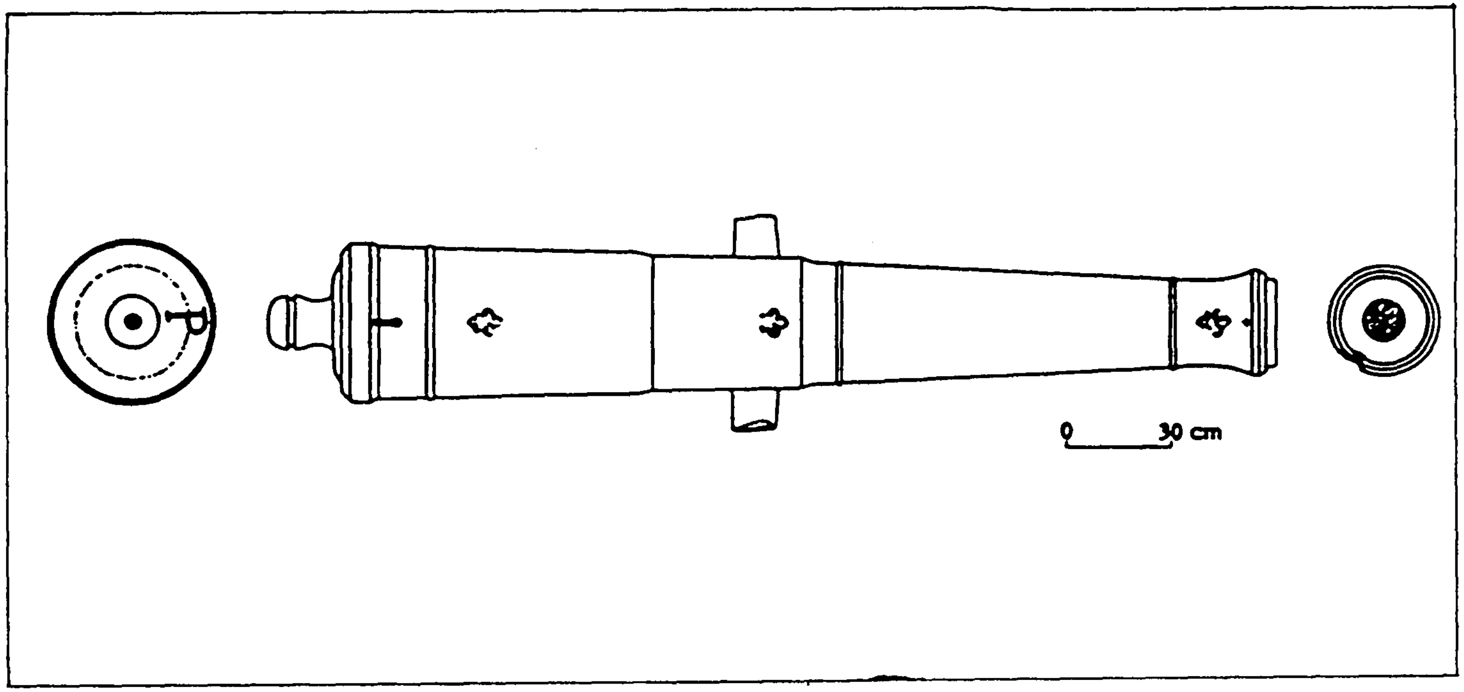


Figure 7-10. Line drawing of a French 12-livre cannon from the MACHAULT showing three fleur-de-lis cast into the top of the gun (from Bryce 1984).

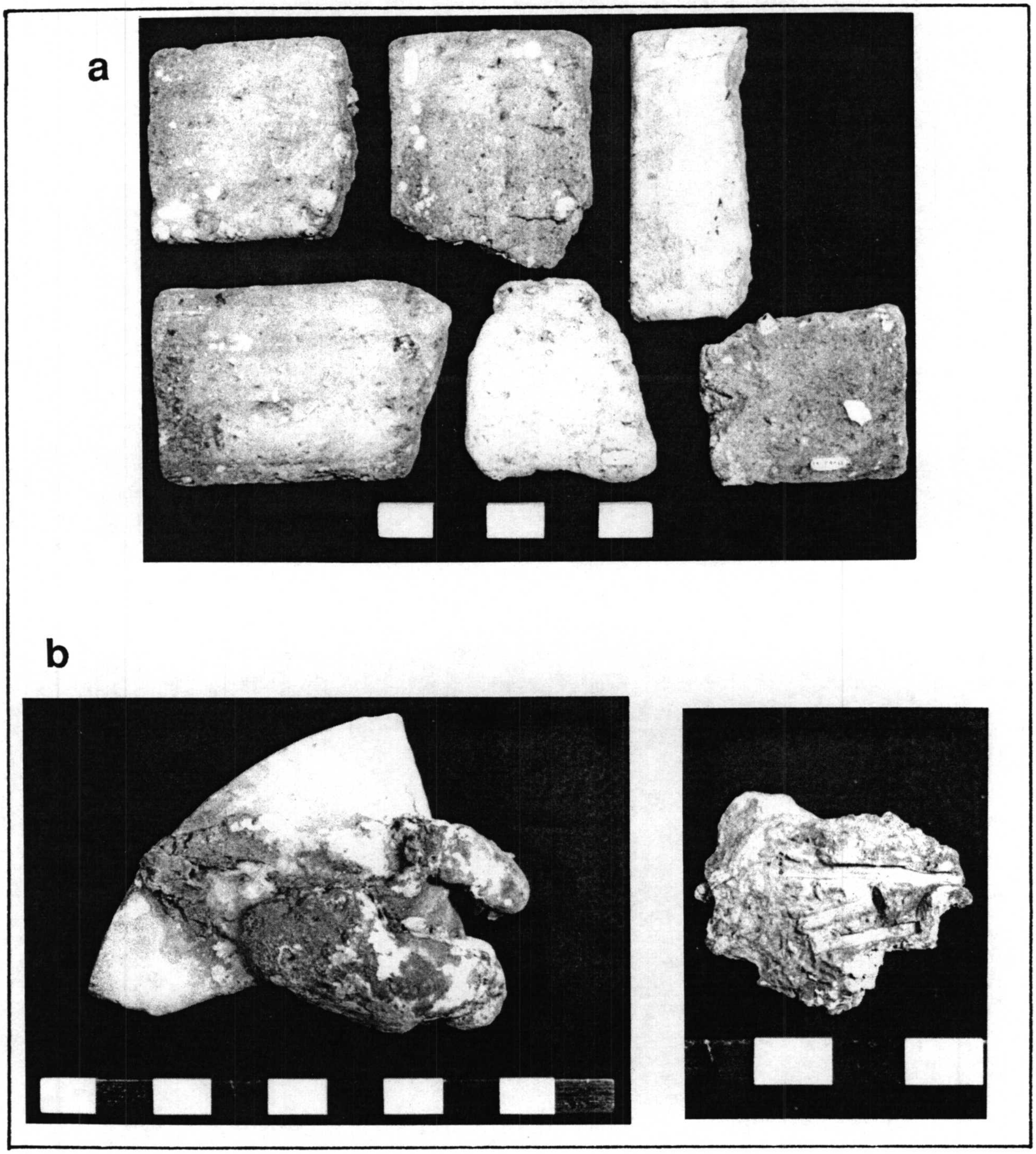


Figure 7-11. (a) Flat, rectangular low fired clay tiles, (IEC89023-IEC89028); (b) Sandstone grinding stone fragment, (IEC89021); (c) Iron concretion exhibiting the molds of three nails.

preserved fragment (Table 7-2). The actual dimensions of a typical tile are estimated at 11.4 cm x 16.8 cm x 2.8 cm (4.5" x 6.6" x 1.1").

Table 7-2
Tile dimensions and Munsell color descriptions

TILES	MUNSELL	COLOR	DESCRIPTIONS	DIMENSIONS (cm)
IEC89023	2.5 YR	5/6	red	11.4 x 9.6 x 2.8
IEC89024	5 YR	7/8	reddish yellow	10.9 x 10.4 x 2.5
IEC89025	5 YR	6/6	reddish yellow	6.9 x 15.5 x 2.8
IEC89026	5 YR	5.5/6	red/light red	11.2 x 16.8 x 2.8
IEC89027	2.5 YR	5/8	light red	11.2 x 11.2 x 2.8
IEC89028	2.5 YR	6/6	light red	11.2 x 13.5 x 2.8

7.8 Sandstone Grinding Stone (IEC89021)

A fragment of a round sandstone grinding stone 38 cm in diameter and 5.6 cm thick was recovered from the site (Figure 7-11b). Concreted to it were several small pebbles. One edge of the grinding stone is worn down indicating some degree of use before it was discarded.

The association of this grinding stone fragment with the stones in the ballast pile indicates a secondary use of this common utilitarian item and illustrates a conservation ethic practiced by 18th century seamen. At one time the grinding stone may have been used aboard ship as a sharpening stone. Upon breaking, it was probably replaced and then thrown below with the rest of the ballast. Alternatively, it may have been picked up from the common ballast pile in port to adjust for alterations in the trim of the vessel.

7.9 Iron Concretions (IEC89032-IEC89043; IEC89049-IEC89050)

One large iron concretion was recovered by Barhanovich and Groves on their initial exploratory dive. By the time it was examined by the project archaeologists one year later, it had deteriorated into 14 large fragments, and a mass of smaller chunks and dust. The only recognizable portion of the concretion was a piece which retained the molds of three square-shanked nails with square heads (Figure 7-11c).

7.10 Interpretations and Conclusions

The analysis of the artifacts from this site and the stratigraphy of the ballast pile suggests that the Chandeleur Islands Site is most probably the result of an 18th century grounding of a vessel of possible French nationality That so few artifacts were recovered from the site, in addition to the lack of any wooden hull remains supports this hypothesis. Concrete evidence for dating the site to the 18th century is provided by only three categories of artifacts - the green lead-glazed ceramics, the lead tube and the cannon gunfounders marks which date the site to no earlier than 1771.

The most convincing evidence for this date is provided by the gunfounders marks, IEC, cast into the right trunnions of three of the cannon. This mark belonged to Johan Jesper Benjamin Ehrencreutz (1752-1774), grandson of Jesper Eliæson (1648-1722) who founded the Ehrendals Bruk (1690-1792) in Sweden. Eliæson became enñobled in 1695 under the name of Ehrencreutz (Elgenstierna, n.d.). The gunfounders mark, IEC, was first used in 1771, although it is not clear how long it continued to be used after the death of Johan J.B. Ehrencreutz in 1774. From information given in Jakobsson's *Artilleriet Under Karl XII:s-Tiden*, the last gunfounders mark of the Ehrendals Bruk was EB, which first appears in 1784. As there are no recorded changes in the marks used between IEC and EB, the IEC mark was most probably in use until 1784. In any event, the vessel grounding event could have occurred no earlier than 1771.

The presence of the fleur-de-lis insignia inscribed or struck into the cannon suggests that they may have originally been part of a specific French arms contract with the Ehrendals Bruk. This avenue of inquiry is in the process of being researched by contacts in the Swedish War Archives and the Army Museum in Stockholm.

The possibility of a French connection is further supported by the two green lead-glazed ceramics (IEC89044; IEC89045) which date to the middle of the 18th century (ca. 1740-1760) on the basis of comparative material from Fort Michilimackinac. Significant similarities between the green lead-glazed earthenware from Ft. Michilimackinac and the two examples recovered from the ballast pile include the ceramic forms (i.e. shallow plates, chamber pots or thick walled storage pots), clay body color and application of the glaze on the interior surface over a thin white or cream colored slip. Of particular interest is the similarity between the section drawing of the shallow plate (IEC89044), Figure 7-4a, and the plate from Miller & Stone (1970), Figure 7-4b. The geographic location of Fort Michilimackinac in northern Michigan on the Straits of Mackinac separating Lake Michigan and Lake Huron is quite removed from the Gulf of Mexico. However, the political and economic influence of the French in both areas during the first half of the 18th century was extensive and is well documented. It is quite possible that finished ceramic products, decorative techniques, glazing formulations or even potters moved between French Canada and the French and Acadian settlements along the northwestern coast of the Gulf of Mexico by way of the Mississippi River.

The geographic location of the ballast pile site in the vicinity of New Orleans and other French settlements along the northwestern coast of the Gulf of Mexico also supports the theory that the nationality of the grounded vessel may have been French. This compliments the archaeological evidence of the fleur-de-lis insignia on the cannon and French or French-influenced ceramics.

Based on the stratigraphy of the ballast pile the following scenario is suggested. Sometime during the third quarter of the 18th century a vessel grounded on a sand bar approximately one nautical mile (1.8 km) east of the windward side of the Chandeleur Islands, and approximately five nautical miles (9.0 km) south of the northern tip of the island chain. The water depths were surely shallower in the 18th century, possibly as little as 3 m deep. It is probable that the vessel was dragging multiple anchors to slow her rate of drift. The magnetic anomalies to the south and east of the ballast pile recorded by the electronic survey (see Section 6) may reflect the magnetic signatures of one or more of these anchors which were left behind. In order to lighten the vessel and pull off the sand bar with the kedge anchors, several tons of ballast were dumped. The ballast was off-loaded according to the way in which the size classes of stone ballast lay in the vessel, i.e. the smallest cobbles on the top were removed first, then the large cobbles and finally the largest, heaviest boulders which were on the bottom closest to the hull. Consequently, the ballast pile which formed in the water to one side, and eventually beneath the vessel as it gradually lightened, was deposited in the reverse of how the stones had been layered inside the vessel. After a substantial amount of ballast stone had been dumped and the vessel still remained grounded, the six damaged cast iron cannon were lifted from the hold and thrown overboard one by one until it floated free. The vessel could then be pulled along the kedge anchor cables to deeper water and set sail.

The additional support for the grounding hypothesis is the lack of hull, rig or structural fittings. Even in the most unfavorable of environments such as surf zones and reefs some preservation of spikes, rails, or chain from wrecked vessels occurs. The absence of these items suggests the possibility that they were already gone or incredibly poor preservation conditions for wrought or cast iron. The Swedish iron cannon survived but as we have seen from the magnetic data their iron content has been significantly reduced by corrosion. If this is the case, then preservation of smaller items may indeed be precluded.

An alternate scenario suggests that the site may be the remains of a shipwreck caused by a vessel which dismasted and "turned turtle" or turned upside down prior to sinking (J.R. Steffy, personal communication 1989). This action would have caused the ballast in the hold to shift and reverse its stratigraphic order without fundamentally altering the vessels center of gravity so that it would have sunk "on an even keel" so to speak.

Ships were typically ballasted along both sides and along the chine of the keel. The central, or keel-line ballast, was always removed or added first (i.e. keel-outward) to prevent the vessel from listing or capsizing. Ballast piles so produced tend to be roughly uniform in shape and stratigraphy. There is nothing irregular about the ballast at the Chandeleur Islands site. As seen in the sonograms (Figures 6-13 & 6-14) and site map (Figure 7-3), the rocks form an ellipsoid shape. Furthermore, the cross-section shows no concentration of one particular size of stone on one side or the other. The hypothesis that the site was formed by lightening a stranded vessel is consistent with what is observed.

If the cast iron cannon were fitted in the hold as permanent ballast then the stratigraphy of the ballast pile from top to bottom would be: cannon, boulders, large cobbles, small cobbles, remains of decking and deck beams if preserved, shell hash and bottom sand. This scenario is consistent with the observed stratigraphy of the ballast pile.

At present, the archaeological data are ambiguous. Neither scenario can be conclusively supported until the magnetic and acoustic anomalies surrounding the site are groundtruthed and identified as being chronologically and typologically associated with the artifacts already catalogued from this site. The materials recovered from the site are all highly resistant to deterioration - 600 kg iron cannon, sheet lead, pipe, ceramic tile, pottery, and rock. During the course of the project, the study team observed storm waves and tidal currents sufficient to break and scatter a stranded vessel. The fine sands provide a poor matrix for any organic preservation and the relatively small grain size allows rapid and continuous movement of these sediments.

The adjudication of these scenarios lie in additional independent data. These data may exist in the form of the anomalies seen peripheral to the ballast-cannon pile which defines the site at present. If these anomalies are the anchors speculated on in this section their identification as such supports the first scenario. If the anomalies are further materials from a wrecked vessel such as additional cannon, structural remains or cargo, then the alternate hypothesis becomes more viable. A scattered, discontinuous assemblage of materials is more consistent with an interpretation of wrecking and subsequent break up.

8.0 SYNTHESIS AND CONCLUSIONS

8.1 Instrumental Characterization and Interpretation

Table 8-1 lists the characteristic magnetic anomaly and side-scan sonar patterns identified by Garrison et al. (1989) for historic shipwrecks. Based on a comparison of these criteria with the results of the instrumental study we must conclude only that it is an historic archaeological site. Instrumentally, it presents good agreement with all eight criteria.

Table 8-1
Anomaly and Side-Scan Sonar Patterns Characteristic of Historic Shipwrecks

1. multiple peak anomalies or spatial frequency - only for small lanespacing (≤50 m)
2. differential amplitude anomalies
3. areal distribution ≥10,000 square meters
4. long gradients and duration
5. axial or linear orientation of anomalies
6. scour areas associated with anomalies
7. exposed structure is geometrically complex and associated with anomalies
8. relative locational permanence

The Chandeleur Islands site has provided an excellent test of the MMS Task II study predictions (Garrison et al. 1989). It also points out the importance of side-scan sonar data to the interpretation of these sites. Further, it affirms the necessity to survey suspected or high-probability areas of historic shipwrecks using a methodology of 50 m lanespacing or less. Also, the utility of groundtruthing was demonstrated.

As shown in Section 6 the interpretation of the site based on magnetic data alone would be difficult without close lanespacing or diver inspection. This is particularly true with the magnetic data developed using the 50 m offset. Groundtruthing would have been necessary to identify the source of the anomaly patterns. With the sonograms of the exposed ballast the characterization of the site without groundtruthing has a high level of confidence.

8.2 Archaeological Characterization and Site Interpretation

The results of the archaeological study supports the results of the instrumental study. The archaeological data support the interpretation of an historic archaeological site; however, the ambiguity lies in the nature and final disposition of the shipwreck incident. Two hypotheses are supported by the data: (a) a stranding, with subsequent freeing of the vessel after lightening, and (b) a wrecking of the vessel.

These alternate interpretations are interesting issues but their ambiguity must not mask the importance of this site. The Chandeleur Islands site is an important archaeologically, representing only the second scientific study of an 18th century archaeological site in the northern Gulf of Mexico. It validates predictions made by the MMS Tasks I and II study by Texas A&M University (Garrison et al 1989). Further, it provides valuable data on preservation in this area of the Gulf. The results of this study provide MMS with invaluable data for future decision-making and management of historic cultural resources in the OCS.

9.0 CONSERVATION OF THE CANNON

9.1 Introduction

During the first visit to the site, the cannon were measured and numbered - 1 through 6 (Figure 7-3). Two of the guns were slightly longer than the others and were possibly of a larger caliber. The study team decided to remove the iron encrustation from the muzzles of the cannon so that an accurate measurement of the calibers could be taken. This was successfully done with the careful use of a hammer and a small cold chisel. In this way it was found that the four smaller cannon were three-pounders and the larger two were four-pounders. The trunnions were also exposed in the hopes that there would be makers' marks that could aid in the identification, origin and date of the cannon. This in turn could help indicate the possible identity of the vessel. Three of the cannon, #2, 3 and 6, had the letters "IEC" cast on the right trunnion (Figure 7-9b). These were the only marks that were found during the initial investigation.

The cannon were generally in a poor state of preservation from being underwater for a long period of time, and also from a number of other pre-depositional causes. Cannon #2 had been badly damaged, having a burst muzzle, and Cannon #5 was badly corroded around the muzzle bell. Cannon #3 had a somewhat off-center bore and was missing one of the trunnions. Both Cannon #1 and #2 had substantial longitudinal cracks in the cast iron, which were also seen in Cannon #4 and #6 after they had been cleaned of their iron concretion at Texas A&M University. The cause of these cracks is uncertain. They could be the result of extensive corrosion or a poor casting technique.

9.2 On-Site Conservation

In long term sea water immersion conditions, an equilibrium is established between the iron corrosion rate, the diffusion of corrosion products and the buildup of surface solids (encrustation) e.g., insoluble corrosion products, shells, sand, pebbles, residual graphite, artifacts, etc.

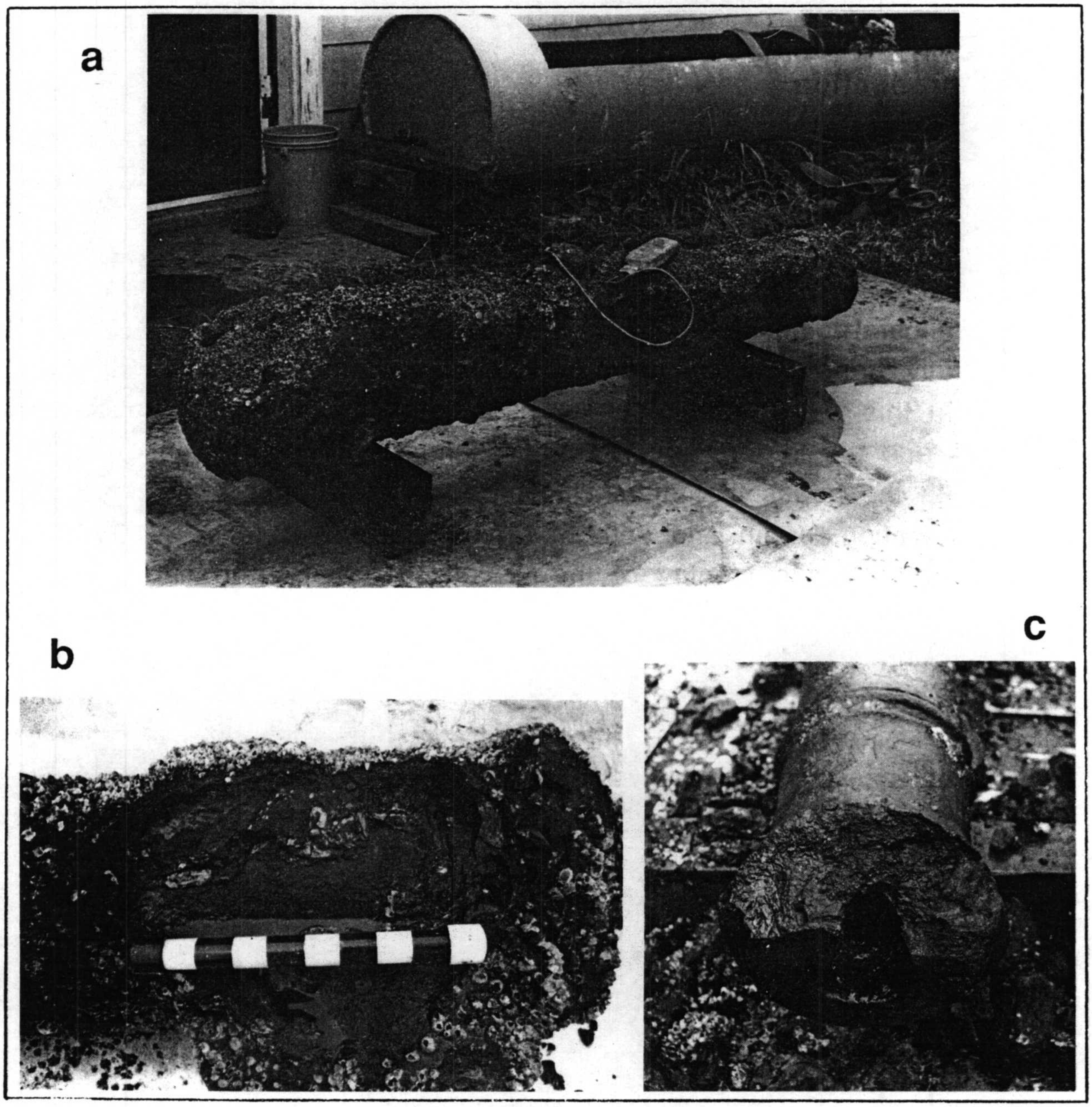


Figure 9-1. (a) Cannon #6 totally encrusted with sacrificial zinc anodes attached to the trunnion. Reduction tank is in background; (b) Extent of encrustation on Cannon #6; (c) Muzzle bell damage on Cannon #6. Scale is 10 cm.

If the object is disturbed or damaged, it can be re-exposed to the surrounding sea water and the equilibrium upset. With the much increased oxygen availability, the iron corrosion rate increases rapidly. Likewise, if the object is removed from the ocean environment and freely exposed to air, the surface will dry out, but the underlying layers will remain moist due to the hydroscopic nature of the retained salts. In addition, the oxidation of some existing ferrous compounds to a ferric state may occur. These changes will inevitably produce some volume changes within the graphite/corrosion product layers, resulting in spalling and some irreparable surface damage.

The cannon were no longer in a stable condition because the trunnions and muzzles were re-exposed to their surrounding environment by the removal of the protective layer of encrustation. Therefore, sacrificial zinc anodes were attached to all of the cannon trunnions by means of heavy copper wire and stainless steel hose clamps (Figure 9-1a). This process prevents the further deterioration of the cast iron cannon as it sets up a galvanic cell. The zinc corrodes at a more rapid rate than the cast iron, since it is lower on the Electromotive Series Scale. While the sacrificial zinc anode corrodes, the exposed surface of the cast iron cannon will be slowly covered with a marine encrustation, which will ultimately prevent the flow of oxygen to the cast iron that could further the corrosion process. Ultimately, when the zinc has corroded away in its entirety, the surface of the cannon should be adequately covered with a new layer of encrustation. This process was initially used in Western Australia on the S.S. XANTHO with very good results (McCarthy 1988). When the team returned to the Chandeleur Islands site in July, after an absence of seven weeks, no corrosion processes could be seen on the surface of the cast iron cannon. In addition, there was already a good growth of marine life and encrustation on the previously re-exposed areas of cast iron. The cast iron had a grey color with no evidence of any orange rust scales on the surface, which is an early indicator of corrosion.

9.3 Removal and Transportation

Two of the cannon, one four-pounder and one three-pounder, were lifted for conservation purposes. The three-pounder was one of the "IEC" cannon (#6) (Figures 7-9a and 9-1a), and the four-pounder was one of the "unknown" guns (#4). The other long four-pounder had the "IEC" mark on the right trunnion.

The two cannon were transported to Texas A&M University. During the trip (ca. 9 hours), they were kept wet to prevent any further corrosion and deterioration of the metal. Upon arrival at the conservation laboratory, the cannon were stored in a steel tank containing a 1% solution of sodium hydroxide in tap water until they could be mechanically cleaned.

9.4 Mechanical Cleaning

Before the cannon could undergo conservation, the iron concretion had to be removed from the surface of the metal. The cannon were lifted from their storage tank and carefully washed to loosen concretion and sand from the surface of the encrustation. The iron encrustation was carefully chipped away by using a two-pound hammer and a small cold chisel. This was done by gently tapping with the hammer and chisel, striking blows at right angles to the surface of the encrustation. This caused the encrustation to crack open in large pieces exposing the surface of the cast iron. Care was taken not to drive the chisel into the surface of the metal, which was extremely soft in places and covered with the wet black corrosion products. Throughout this process, the cannon were kept wet which aided in the cleaning The encrustation varied in thickness from 2.5-7.5 cm, and in composition from soft to hard (Figure 9-1b). It was not necessary to remove all the concretion initially, as it is easier to remove the difficult spots of concretion after a short period of time in the electrolytic tank. In this way, approximately 95 kg of concretion was removed from Cannon #6 and an additional 72 kg of ballast stones which were attached to the encrustation were removed from the cannon.

Additionally, 110 kg of concretion were removed from Cannon #4. There were no ballast stones attached to this cannon encrustation.

The bores of the cannon were surprisingly easy to clean. Each had a plug of only 10-15 cm of hard concretion sealing off the muzzle of the bore. Great care was taken in cleaning in the event that the cannon may have been loaded. The remainder of the barrel was filled with a loose black sandy material containing fragments of linen material. This material had no odor and proved to be sea sand, which was easily washed away. The vent hole was plugged with a small twist of hemp rope. Sealed into the concretion of Cannon #4 were numerous small pieces of wood and twigs, possible dunnage, as well as a few pieces of rope. Samples of these will be analyzed.

After the concretion was removed, the cannon were rinsed with water and stored in the 1% solution of sodium hydroxide in fresh water.

9.5 Electrolytic Reduction

After 200 years underwater, the porous graphitized surface layers of the cannon were heavily impregnated with chlorides from the sea water. The purpose of this stage of the conservation process was to remove the accumulated chlorides from the metal and reduce the iron corrosion products. This was done to minimize post-treatment corrosion caused by prolonged exposure to the atmosphere. Subsequent spalling of the surface layers, which eventually destroys all surface features and identification markings from the cannon, is also inhibited. The chlorides were driven from the surface layers of the cannon by electrolytic reduction using rectified d.c. current and 300 gallons of 2% sodium hydroxide in water as an electrolyte. The two cannon were placed in the same tank, with the cannon acting as the cathode and the mild steel tank acting as the anode. The cannon were drilled and tapped to take a 3/8 inch steel bolt that was connected to the power supply via heavy duty copper battery cables. The steel tank was connected in a similar manner to the power supply.

In an electrolytic cell, the applied current causes the cations to migrate towards the cathode and the anions towards the anode. Therefore, the chloride ions migrate from the cannon (the cathode), into the electrolyte and towards the anode by an electro-osmosis effect. During this process, hydrogen is evolved at the cathode and oxygen evolves at the anode. At the same time, the oxidized products in the porous graphitized layer are reduced to a more stable form. The hydrogen that bubbles off also aids in the mechanical cleaning of the artifact by removing small pieces of concretion from the surface of the cannon.

For the electrolytic reduction process, an initial d.c. current of 10 volts was chosen with an amperage of 25 amps per cannon. After a short period of time, the conservators discovered that this was not satisfactory as the mild steel tank was going into anodic dissolution, causing the steel tank to disintegrate. To prevent this, the sodium hydroxide solution strength was increased to 4% in fresh water and the amperage was increased to 50 amps per cannon. The setup was closely monitored and was found to be satisfactory and working well.

The chloride ion concentrations were carefully monitored by standard mercuric nitrate titration. When the chloride ion concentration reached approximately 4000 ppm (parts per million), the electrolyte was changed. This level was reached in about two weeks, resulting from the high initial level of chloride ions (500 ppm), high amperage (50 amps per cannon) and high pH from the 4% solution of sodium hydroxide.

At the final stage of electrolytic reduction, the chloride levels can be reduced to less than 30 ppm by changing the electrolyte solution to 5% $NaC0_3$. This is usually done when the chloride level reaches 50 ppm.

9.6 Final Rinsing

The cannon will be boiled in successive baths of de-ionized water to remove the residual chlorides from the porous surface metal. Sodium glucoheptomate will be added to the de-ionized water to prevent oxidation of the surface cast iron. Quantitative chloride tests will be used to monitor the decreasing chloride levels. When the rinsing is complete the chloride level will be less than 10 ppm.

9.7 Protective Sealant

The cannon will be boiled in a final bath of tannic acid in de-ionized water. While still hot they will be removed from the solution and dried using industrial hot air guns. To protect them from oxidation, a 10% solution of tannic/phosphoric acid will be painted on the cannon. This coating also gives the cannon an attractive black finish.

The final step in the conservation process is a coating of micro-crystalline wax (Witco 180M), which seals the cast iron from detrimental affects of the atmosphere. The cannon are submerged in a bath of molten micro-crystalline wax (350°F.). The hot molten wax penetrates into the porous surface layer of the cast iron and hardens upon cooling. Excess wax can be easily removed from the surface of the cannon by localized heating.

Both the tannic/phosphoric acid coatings and the micro-crystalline wax sealant are reversible, by submerging the cannon in a bath of boiling water.

9.8 Description

The measurements of the cannon quoted are not final, and should not be treated as such. Accurate measurements will be taken when their conservation treatments are complete.

The four-pounder cannon has a length, measured from the muzzle to the base ring, of 203 cm. The bore length is 190 cm and the bore diameter is 9 cm, giving the cannon a calculated calibre of 22.33. The smaller three-pounder has a length of 160 cm. The bore length is 150 cm and the bore diameter is 7 cm. The calculated calibre is 21.13.

The cannon are fairly standard models dating to the late 1700s, with no real outstanding features. Both have bell shaped muzzles, with a single round in front of the bell, and flat breeches with a rounded knob shaped cascabel. The cascabel was missing from the four-pounder and has separated from the three-pounder, as it only consisted of graphitized metal. The trunnions are located on the lower horizontal extremity of the gun tubes.

The vent field is relatively short with a conical depression for the vent hole. The holes were plugged with twists of hemp. There were no notches chiselled on the base ring, nor on the muzzle bell for sighting and elevation readings.

The reinforcements are separated by standard reinforcing bands which have rounded fillets on either side, as do the astragals.

On the first and second reinforcements, as well as on the base, there are fleur-de-lis inscribed on the top of the barrel (Figure 7-9c). These are in the same places on both cannon. The fleur-de-lis may have been struck or incised. This will be examined after the cannon have completed their conservation treatment.

The three-pounder had the letters "IEC" cast on the right trunnion (Figure 7-9b). These letters refer to the Swedish maker Johan Jesper Benjamin Ehrencreutz of the Ehrendals Bruk (Foundry) dating to between 1771 and 1784. There were no visible marks on the left trunnion of either cannon. The right trunnion of the three-pounder had corroded away completely.

The four-pounder, was in a poor state of preservation. A large part of the breech has completely corroded and parts of the muzzle are gone with numerous corrosion holes in the barrel. A large portion of the muzzle bell from the three-pounder is missing (Figure 9-1c), possibly due to a fracture break. The entire conservation treatment should be completed in about nine months.

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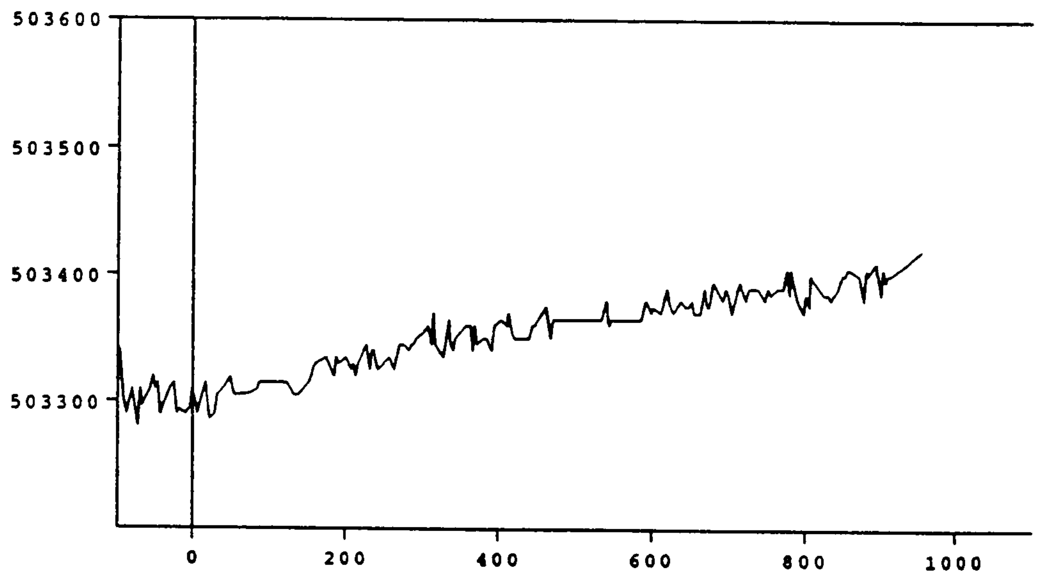
APPENDIX A

LINE 01S



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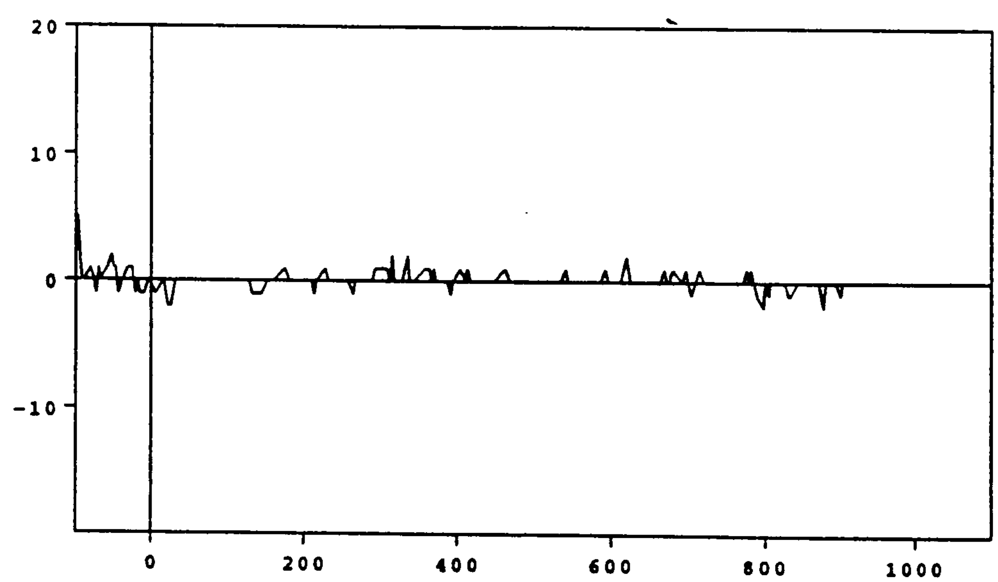

*X coordinate is gamma (nanotesla) units.
Y coordinate is distance along line in meters

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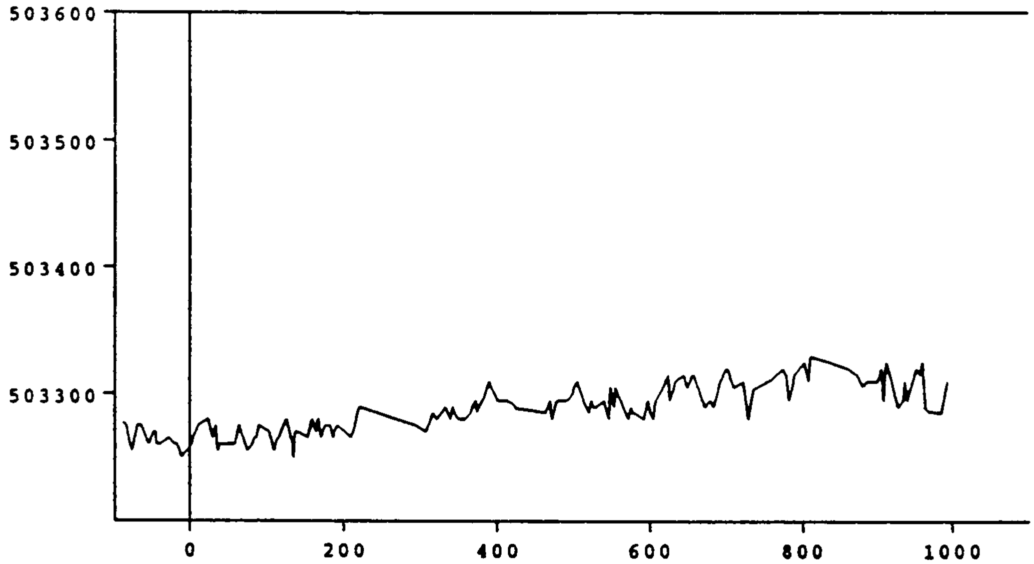

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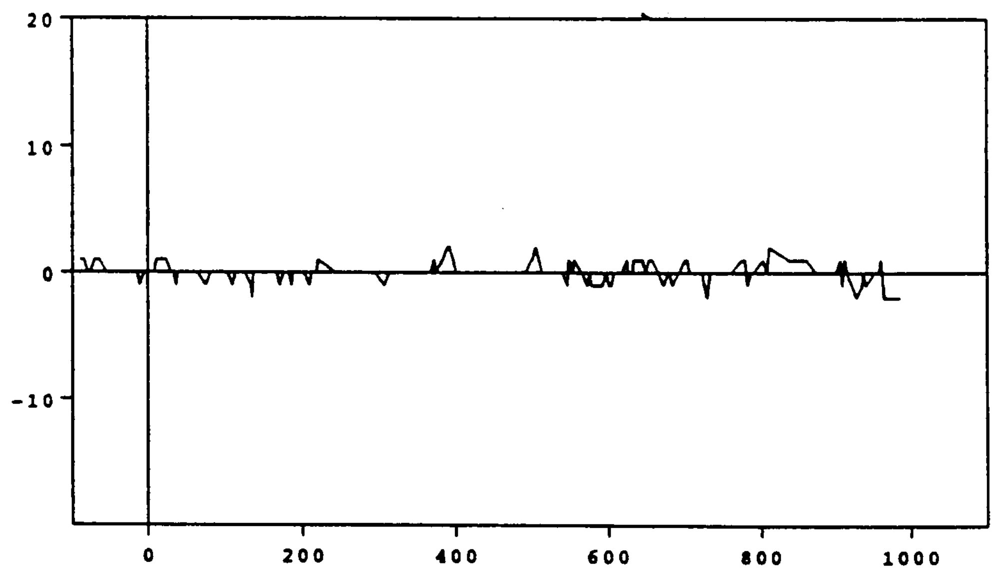

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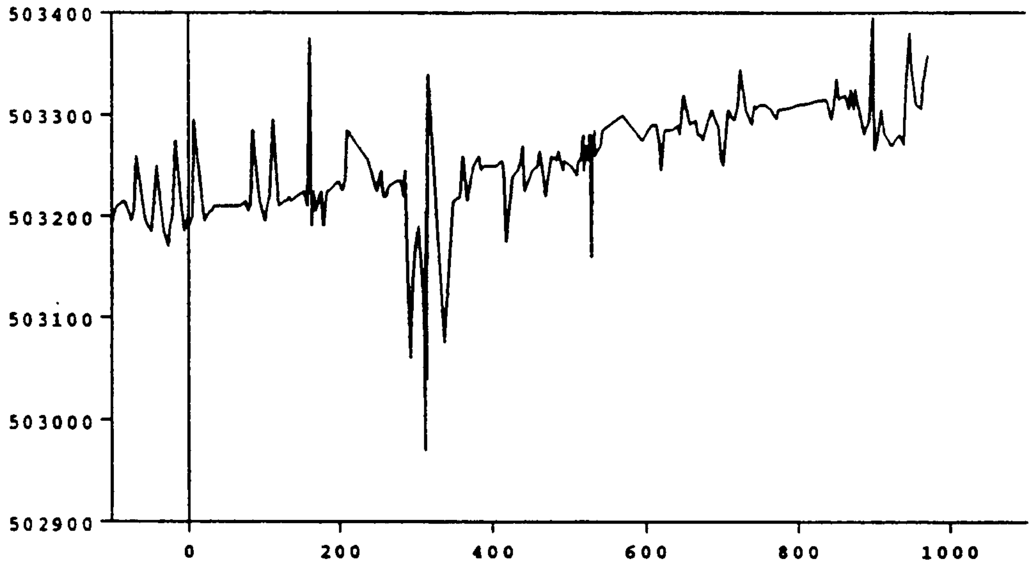

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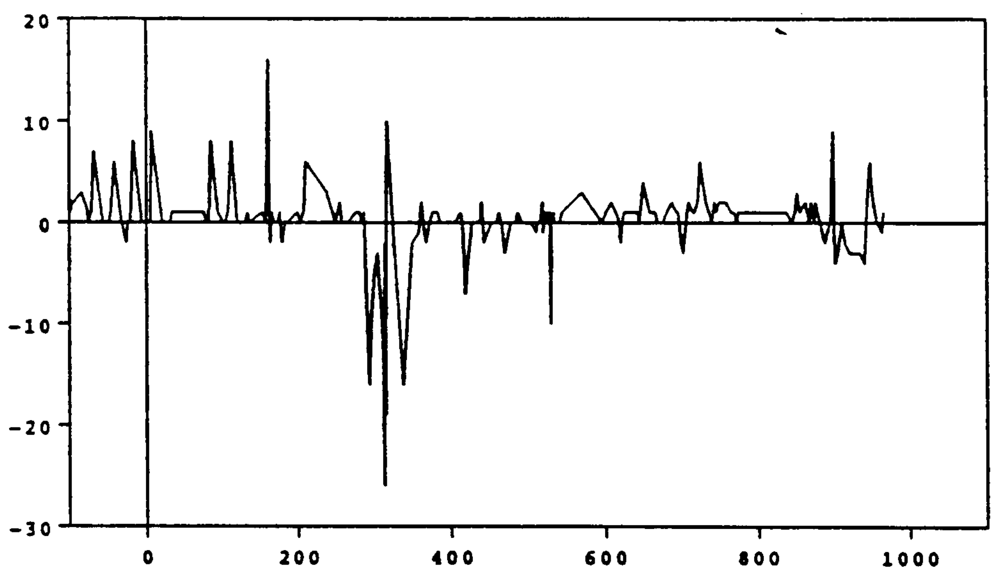

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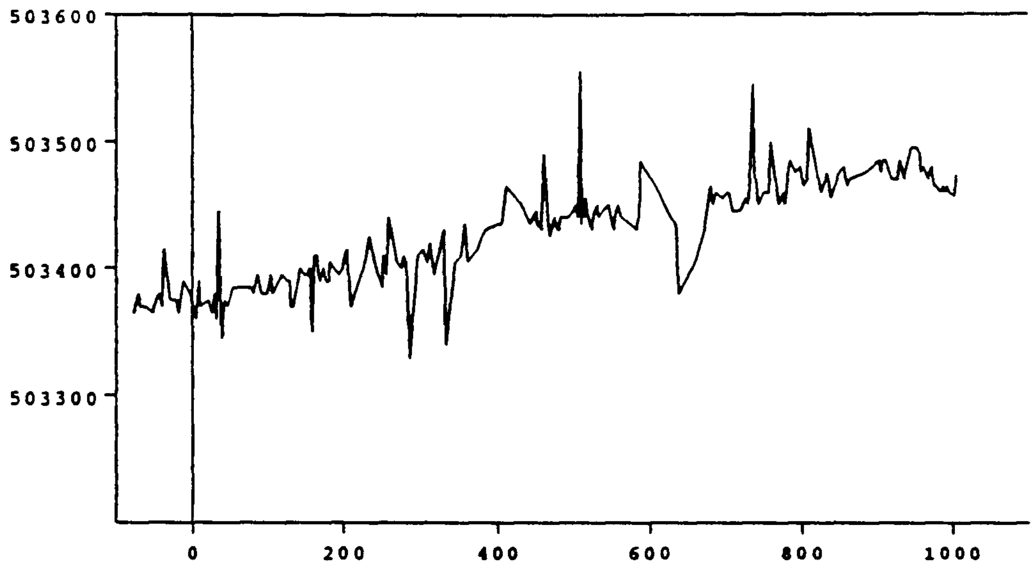

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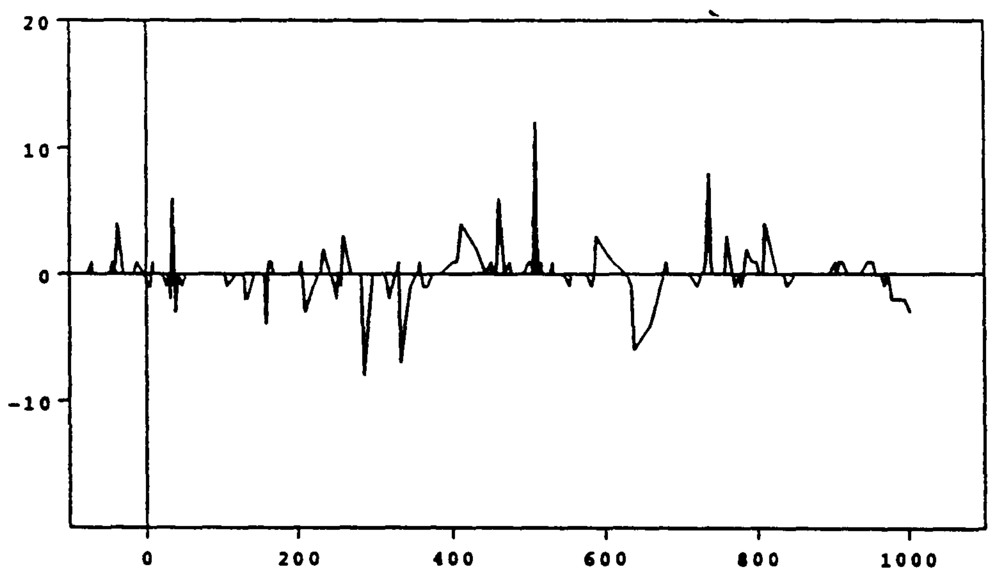

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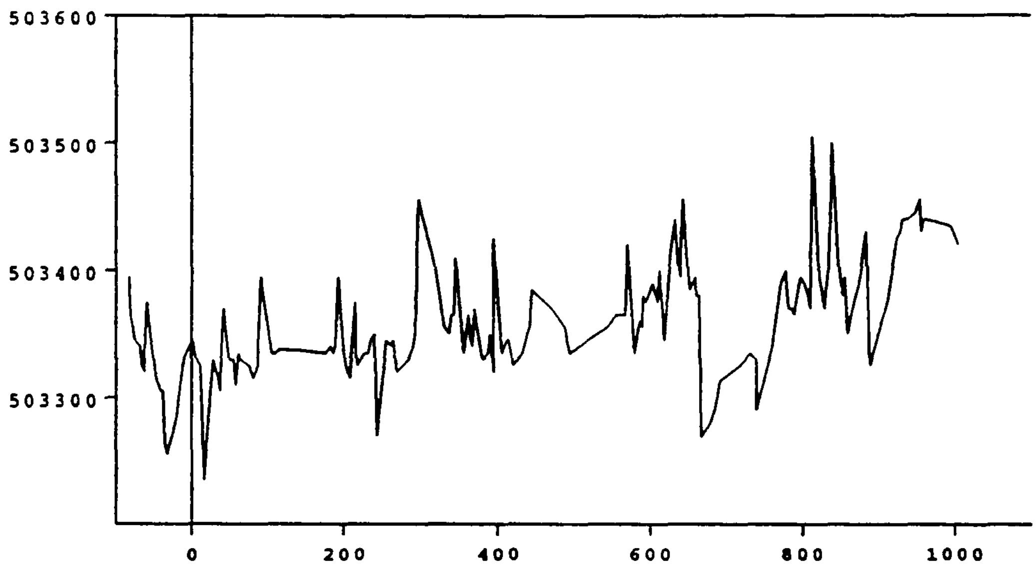

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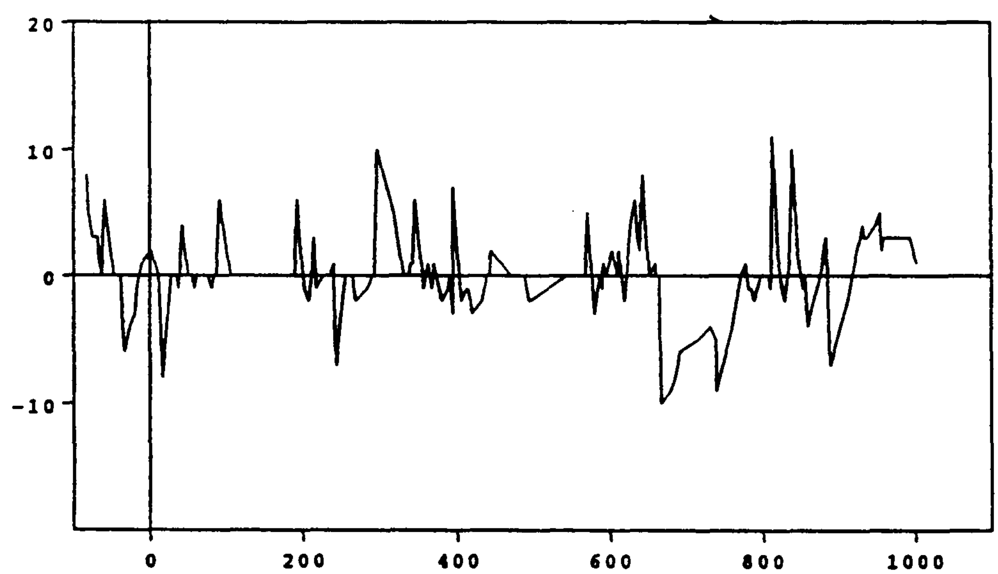

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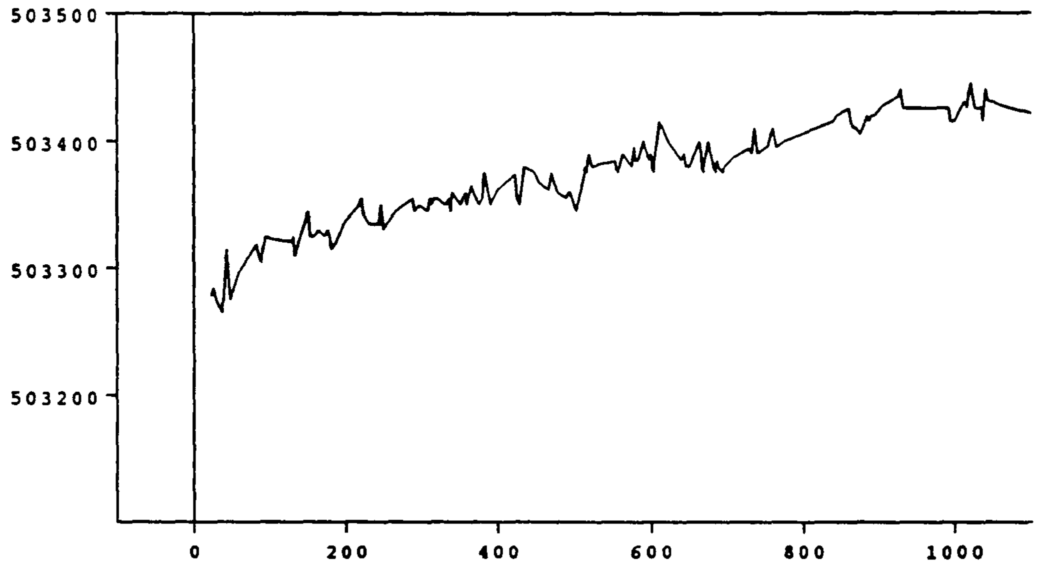

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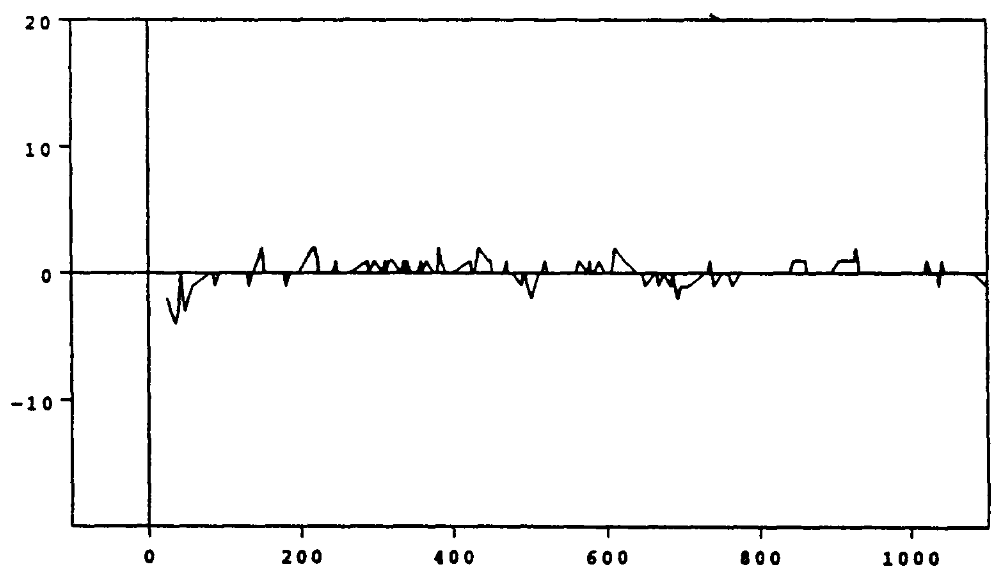

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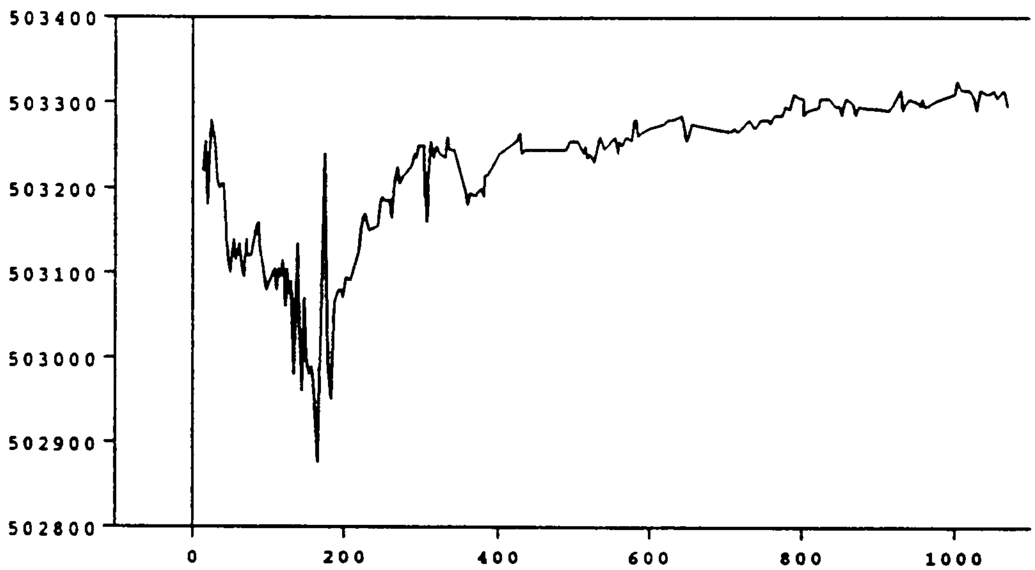

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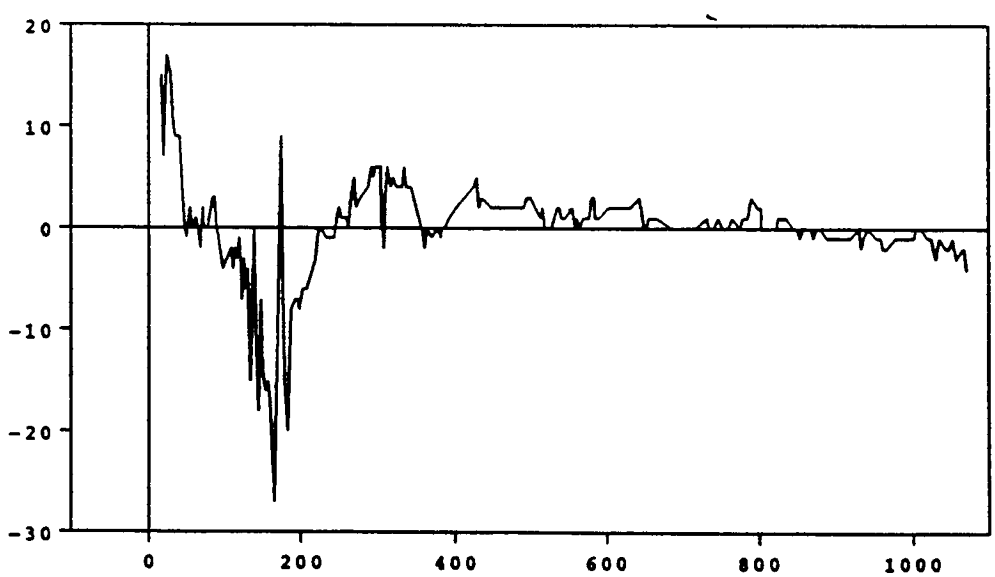

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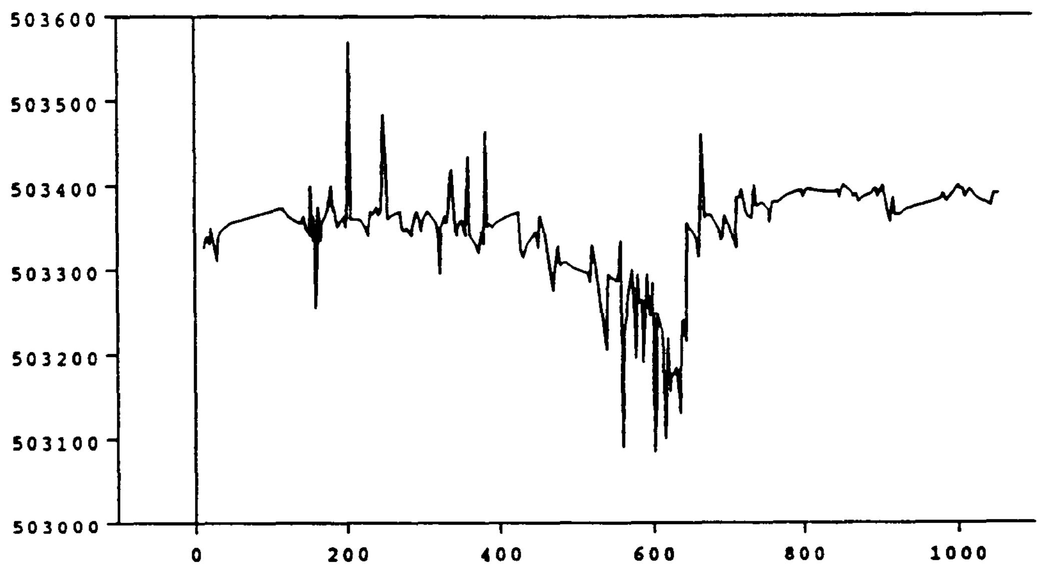

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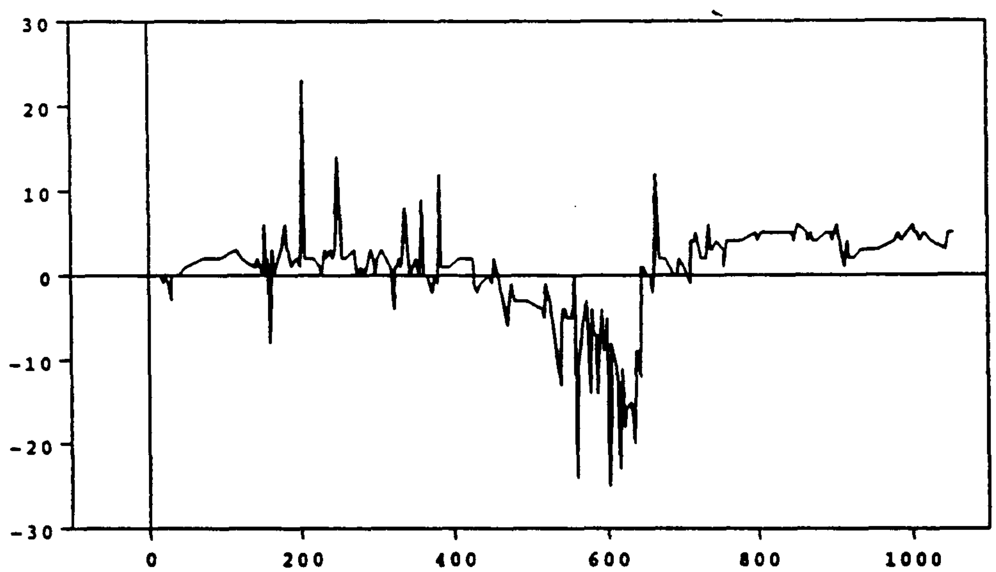

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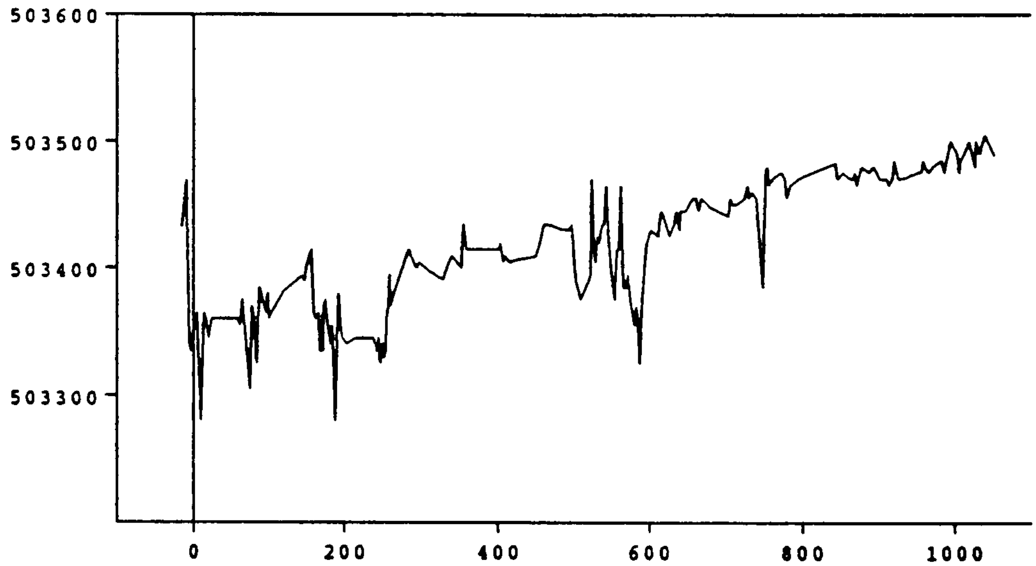

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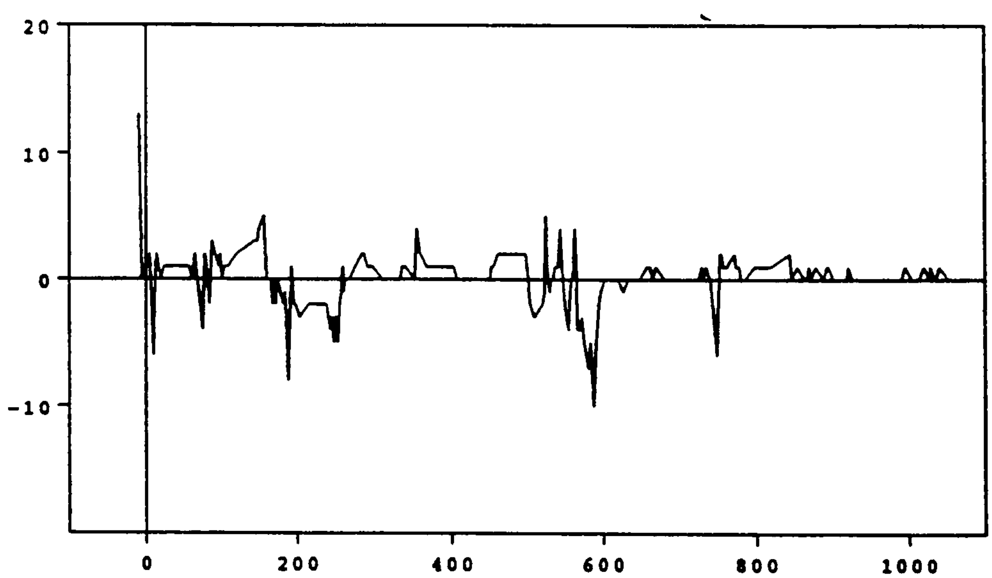

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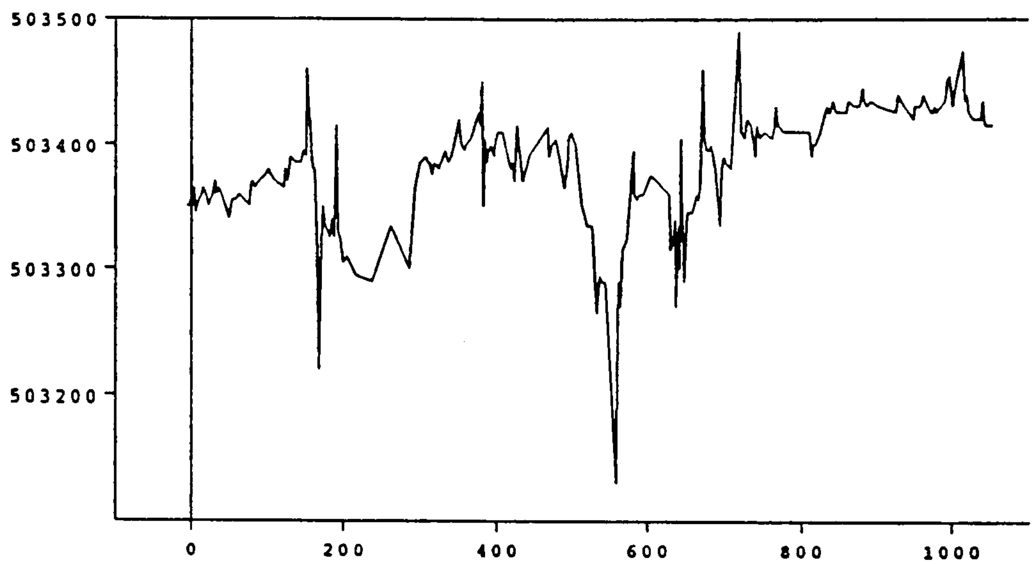

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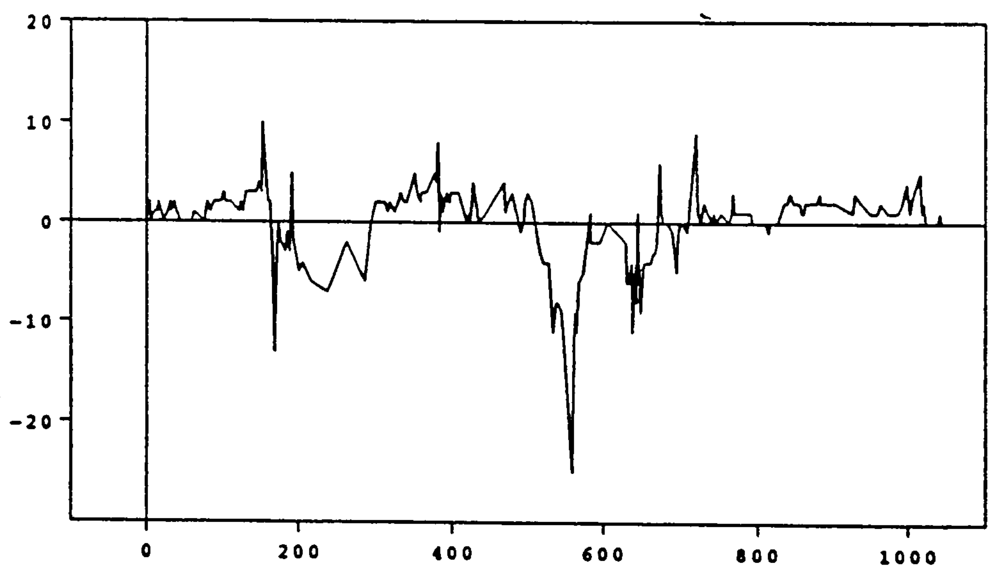

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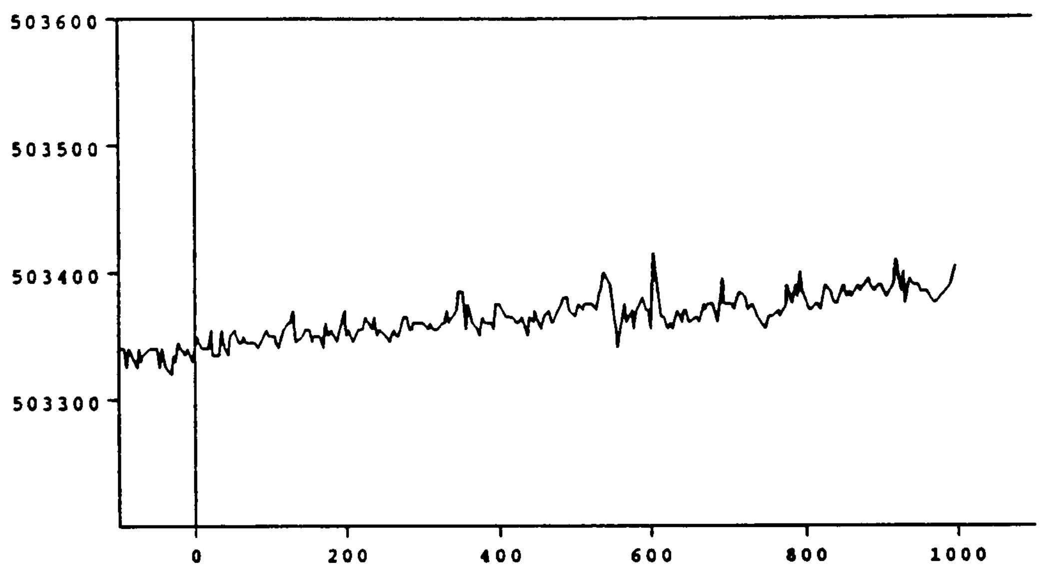

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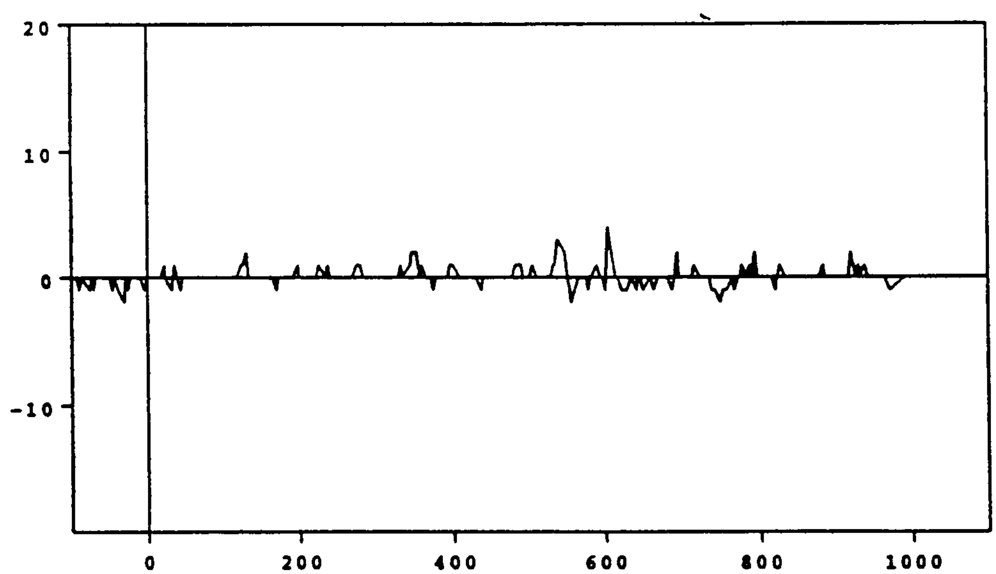

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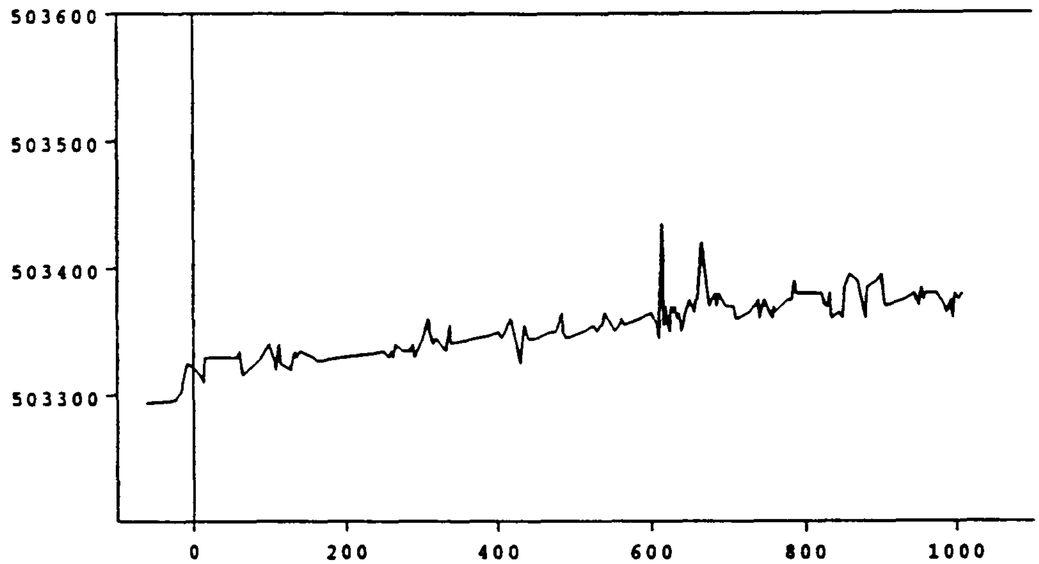

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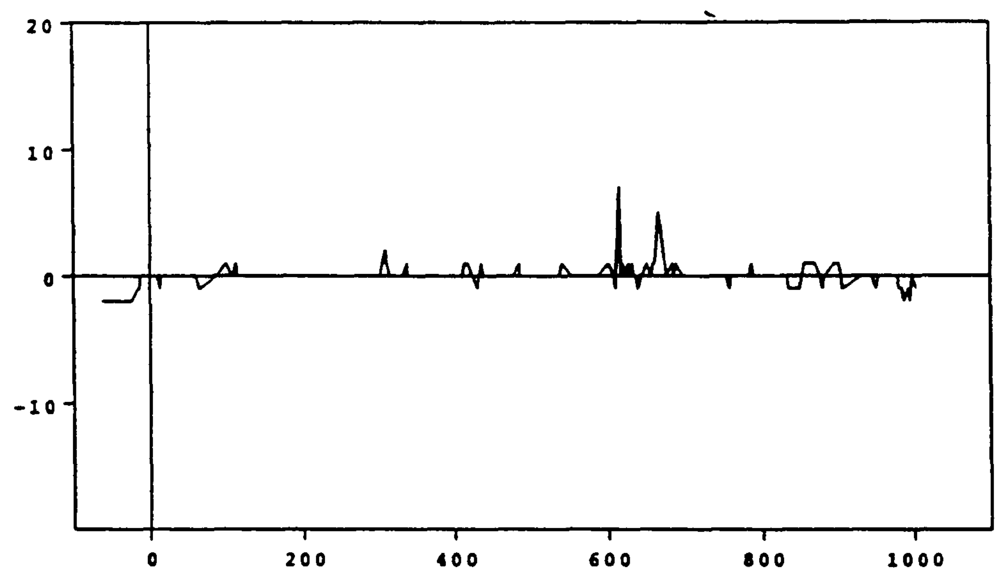

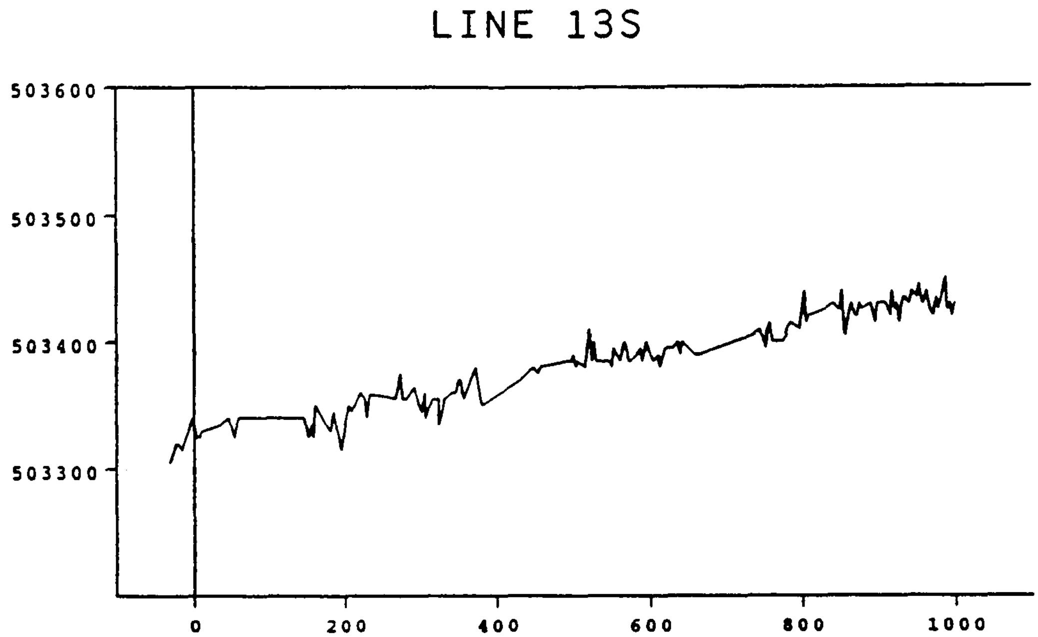
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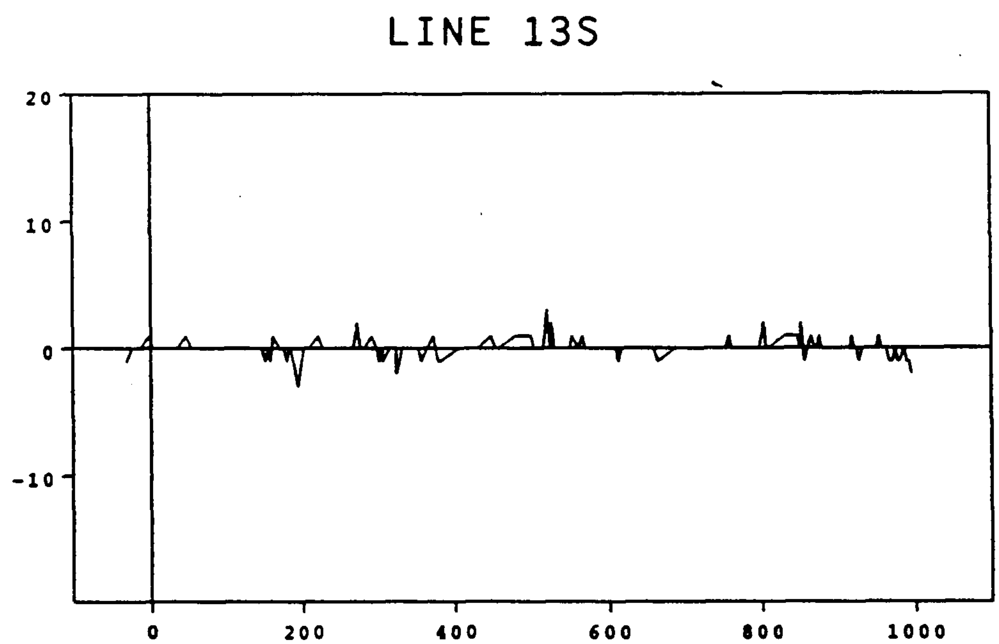
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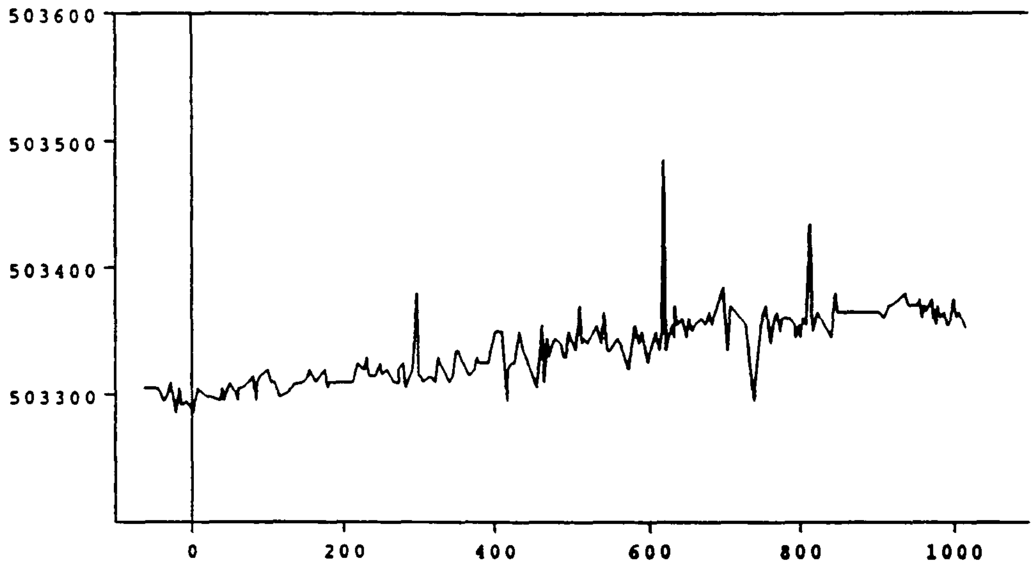

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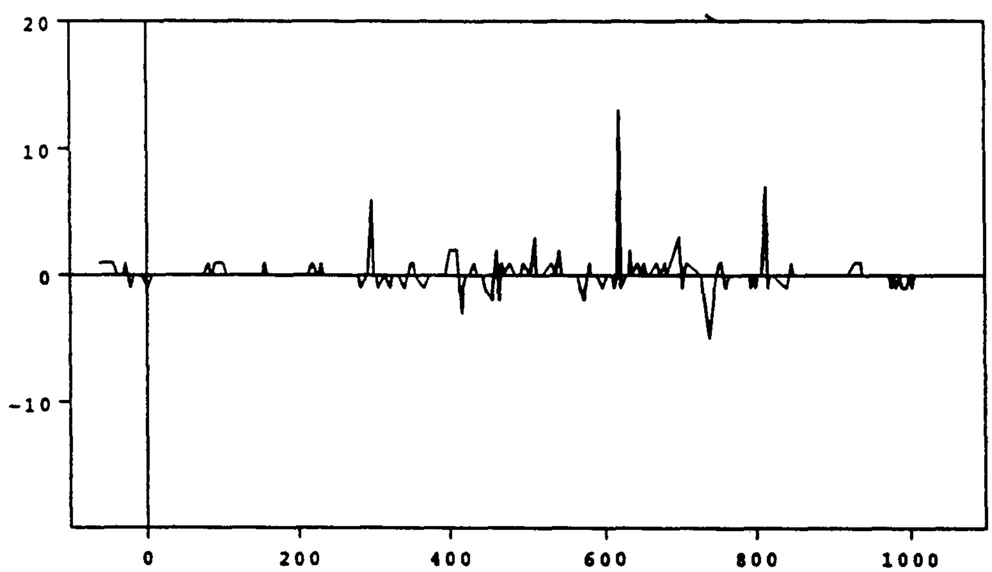

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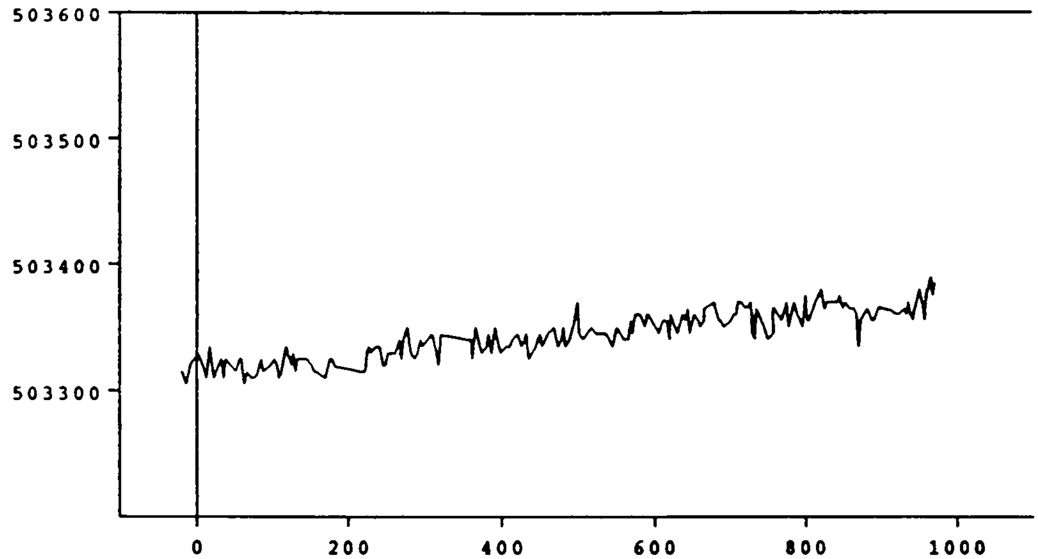

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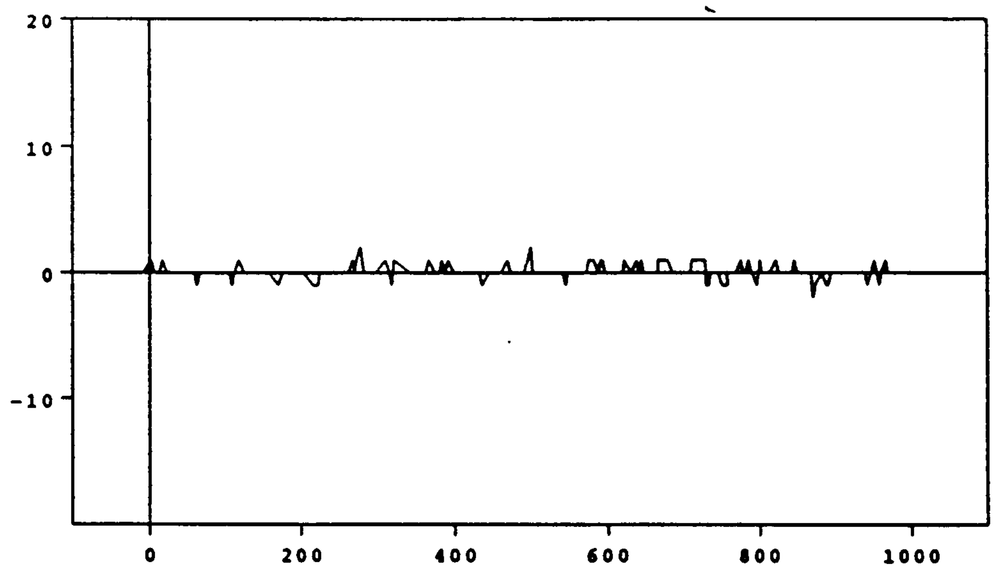

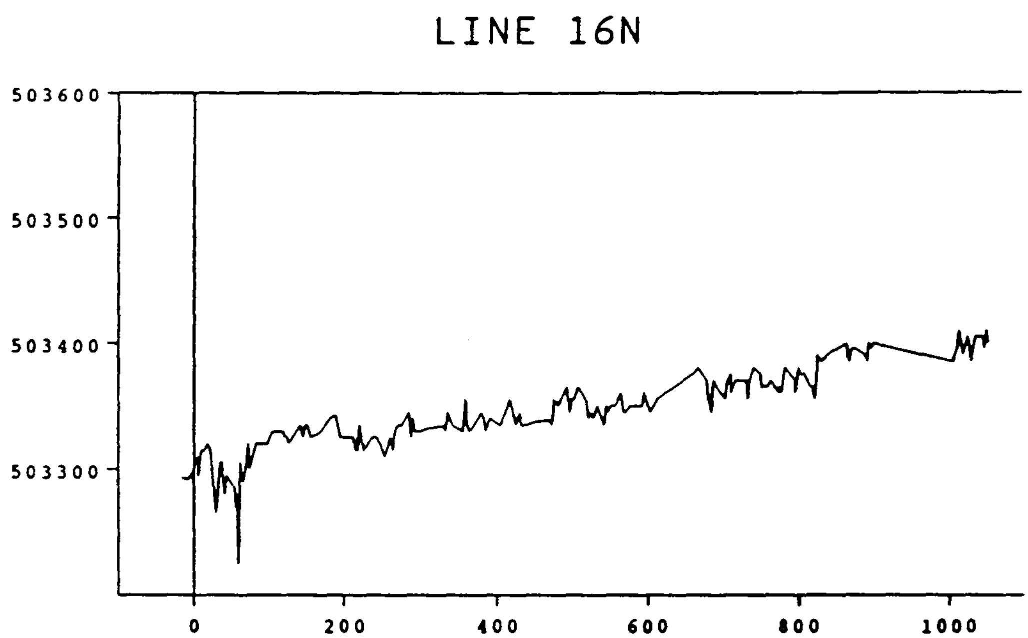

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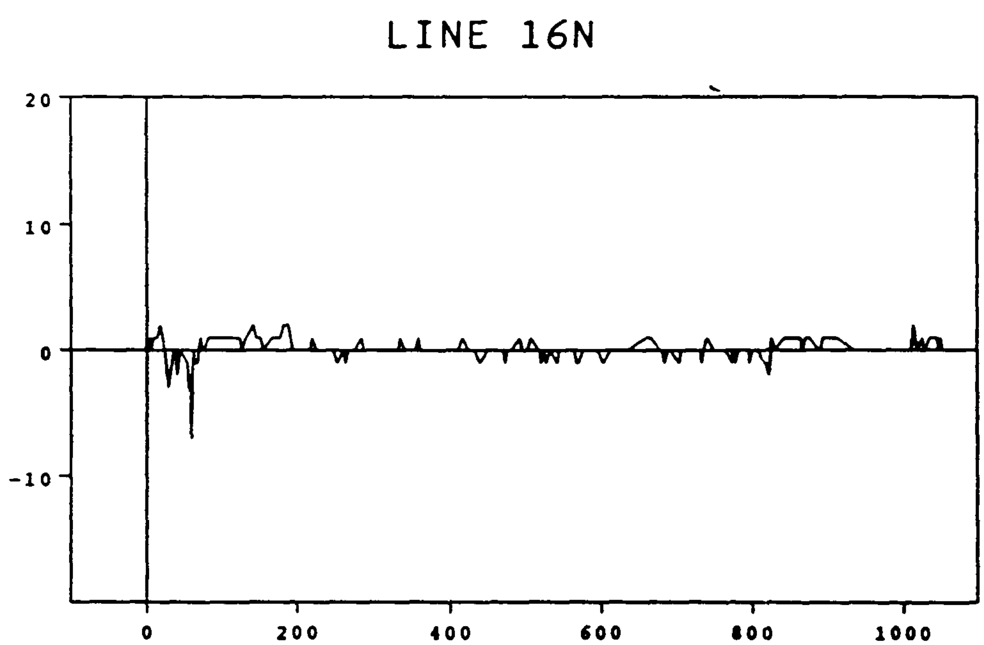

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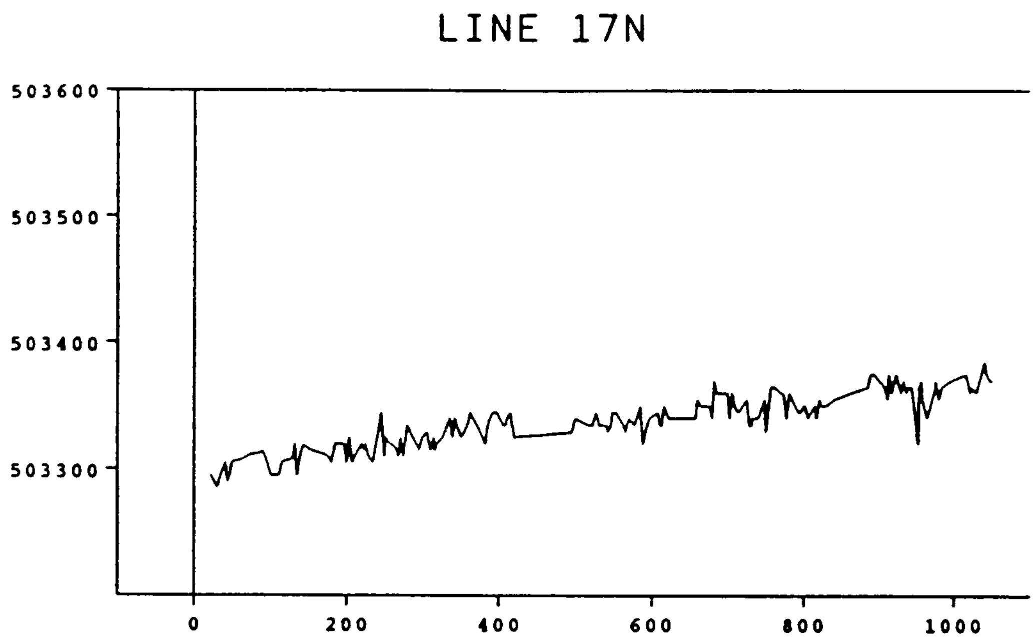
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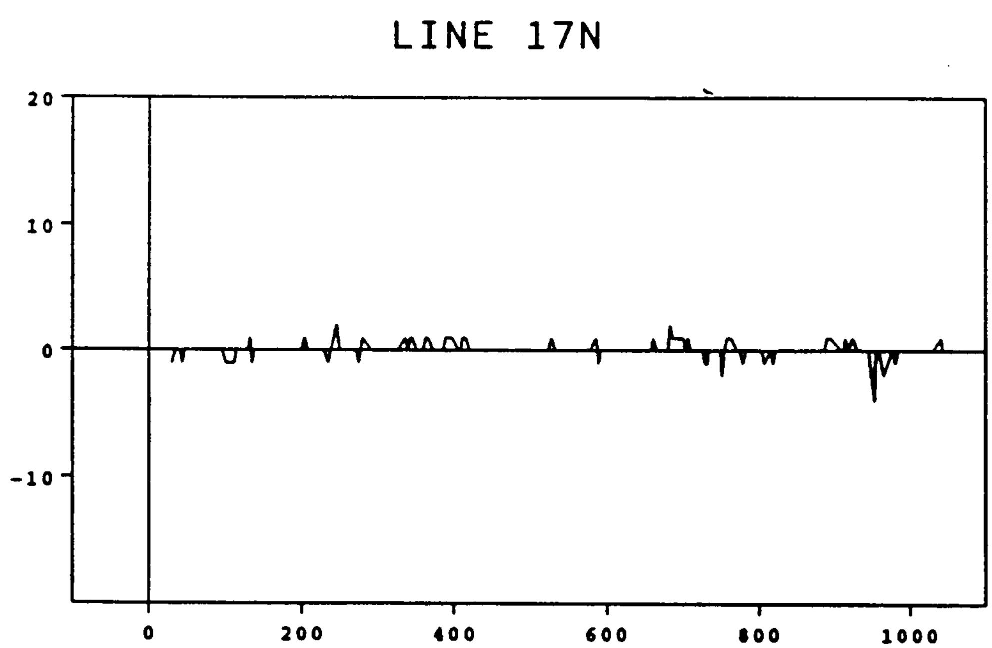
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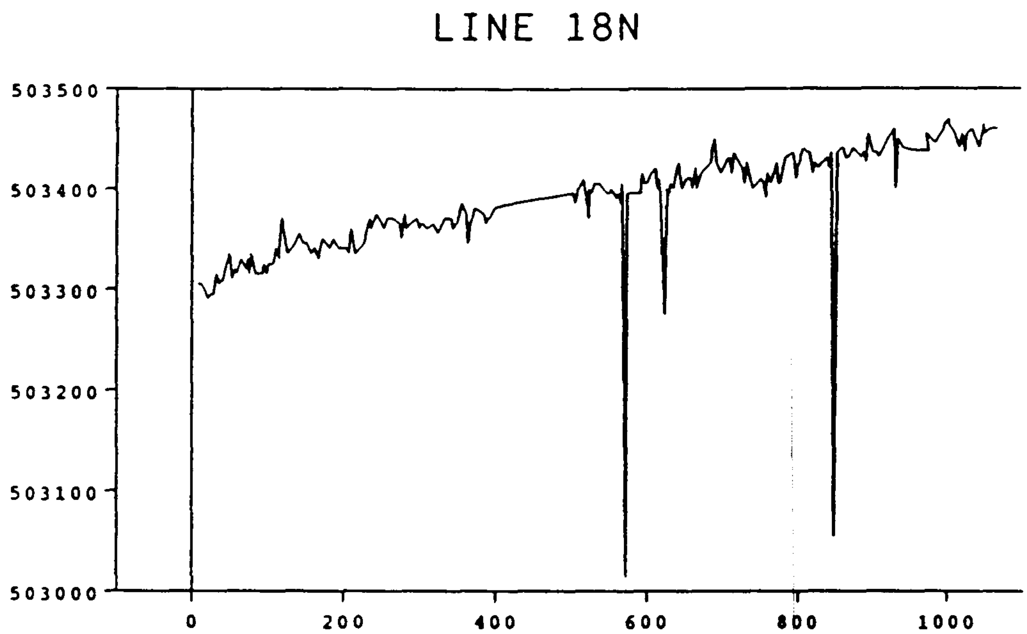
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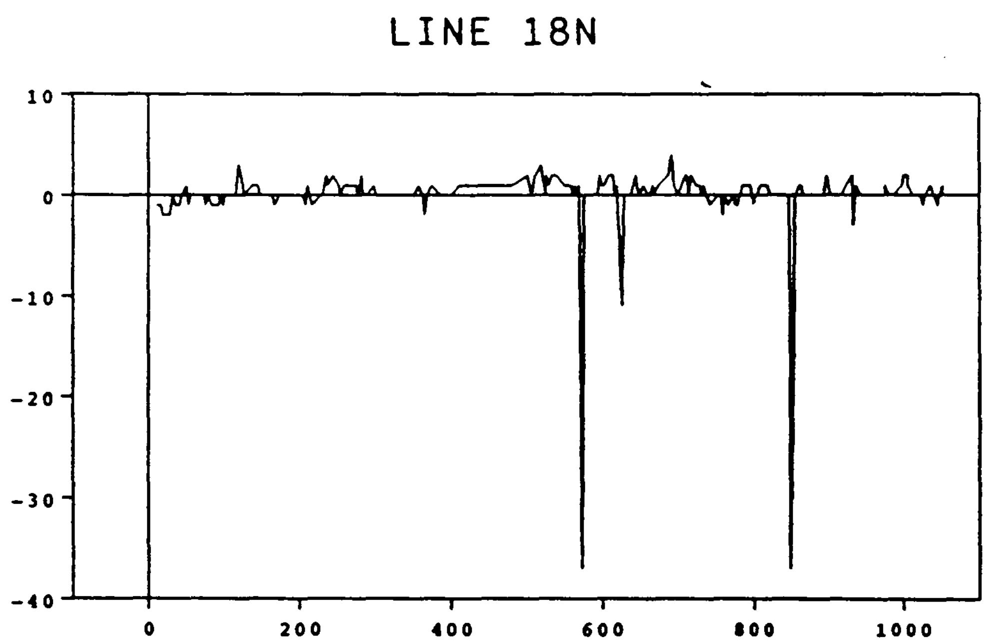
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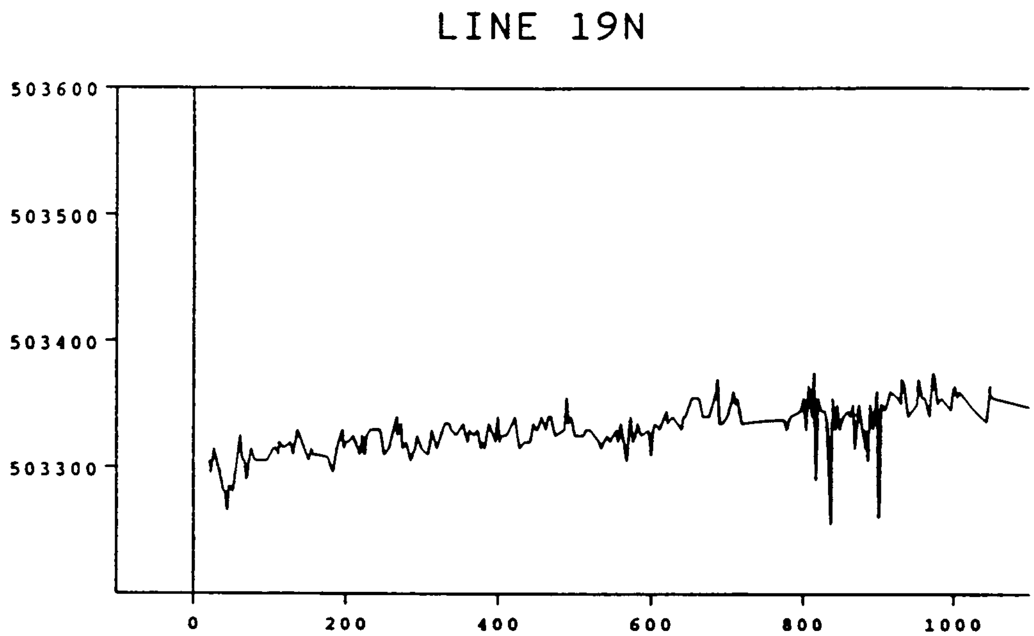
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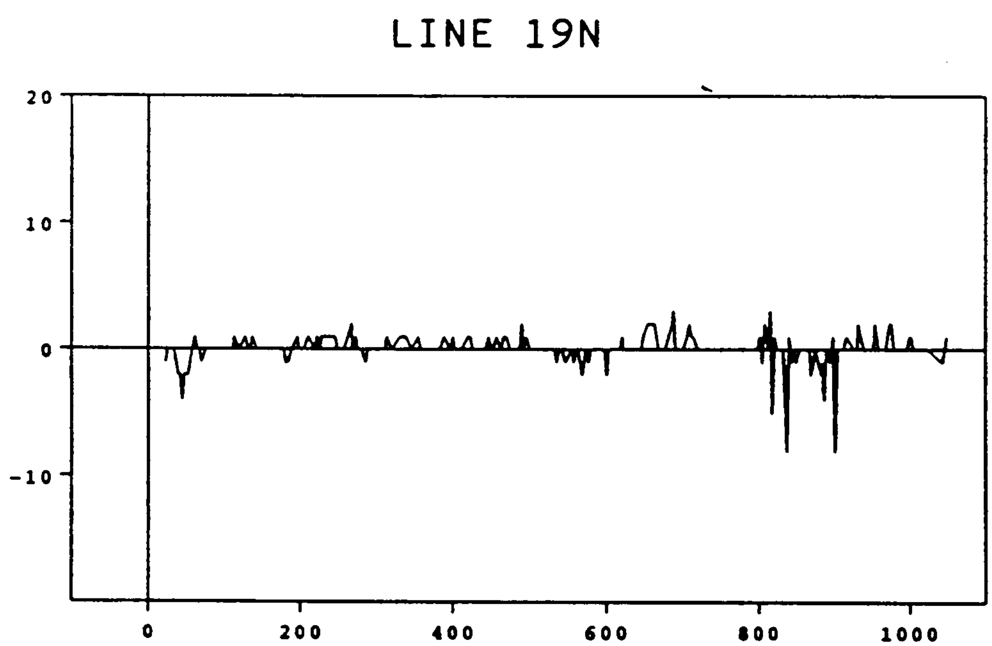
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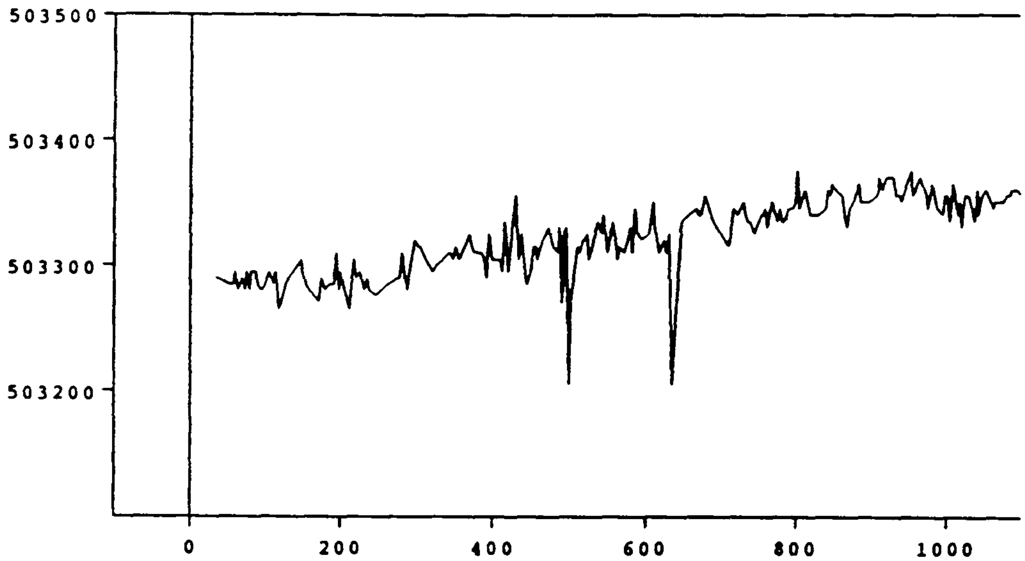

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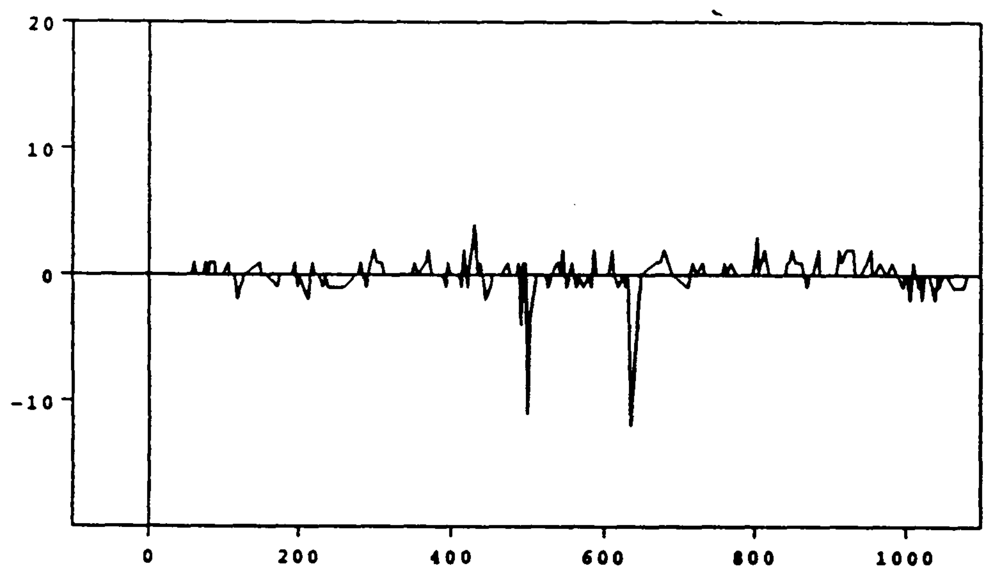

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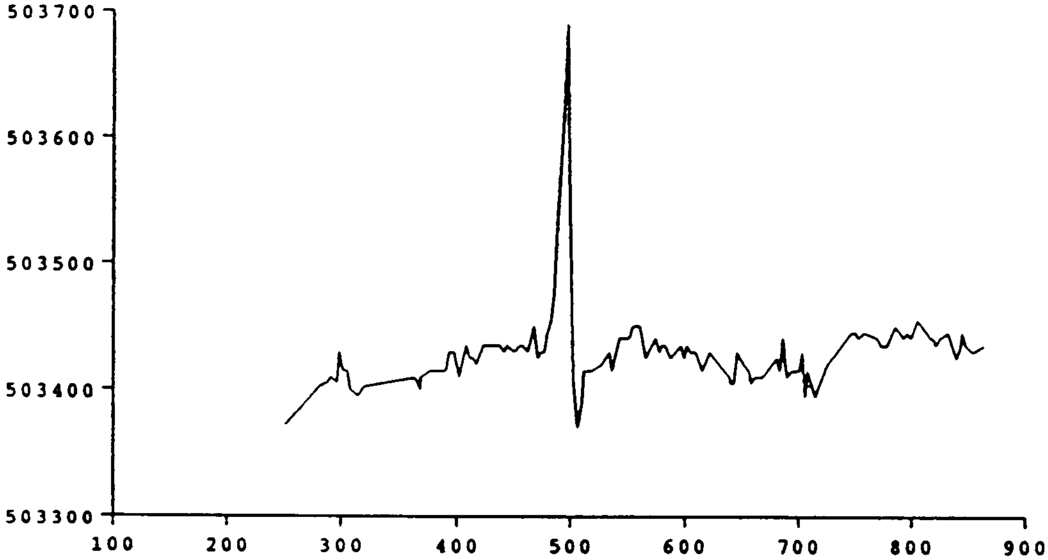

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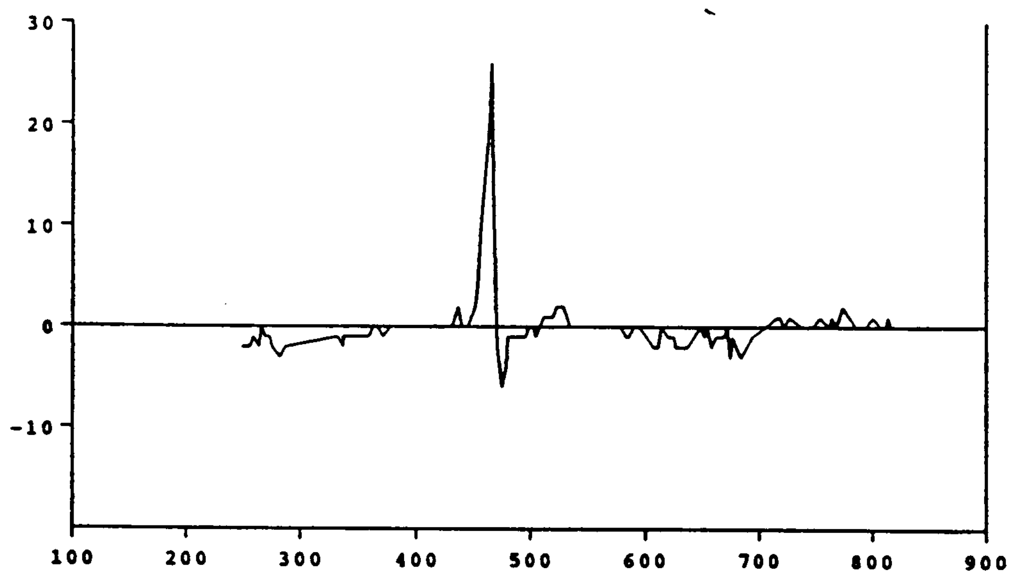

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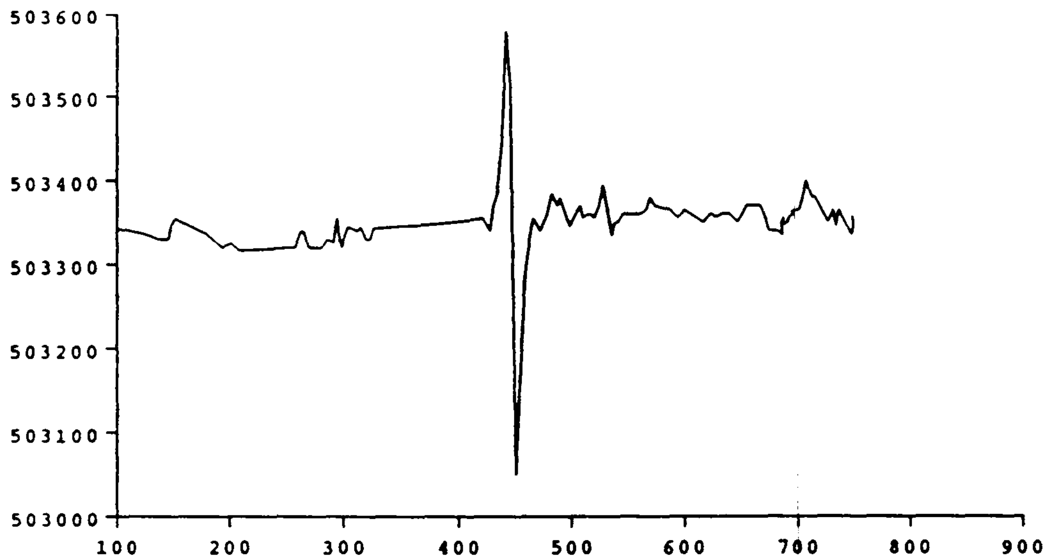

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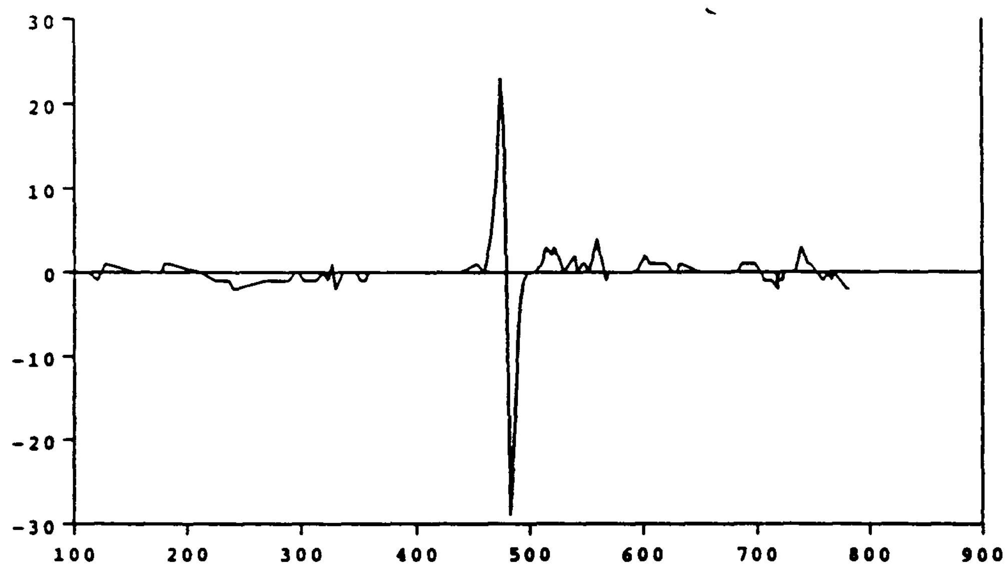

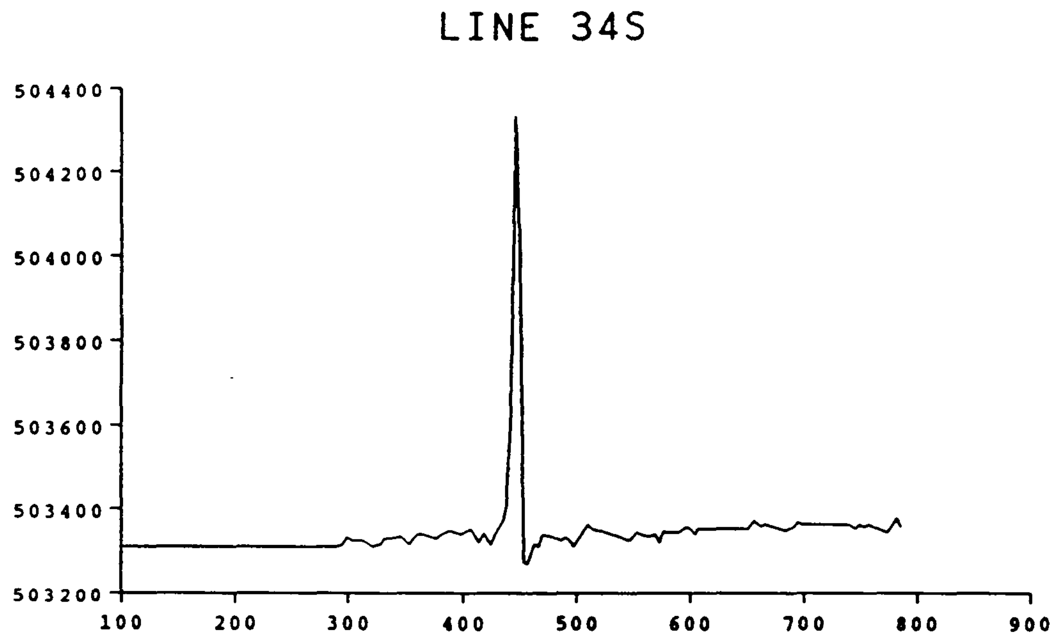
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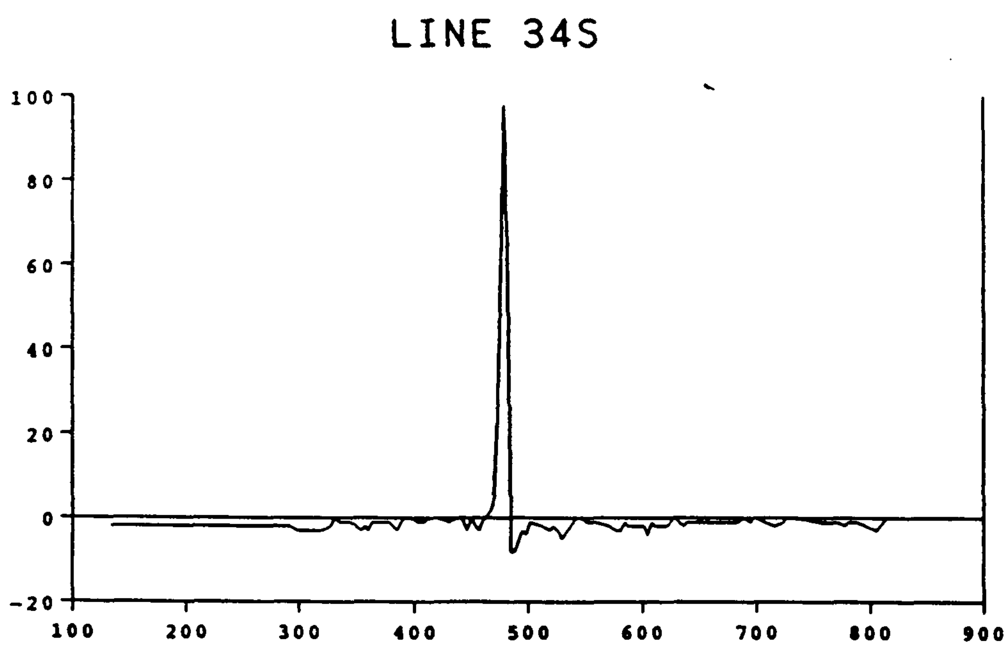
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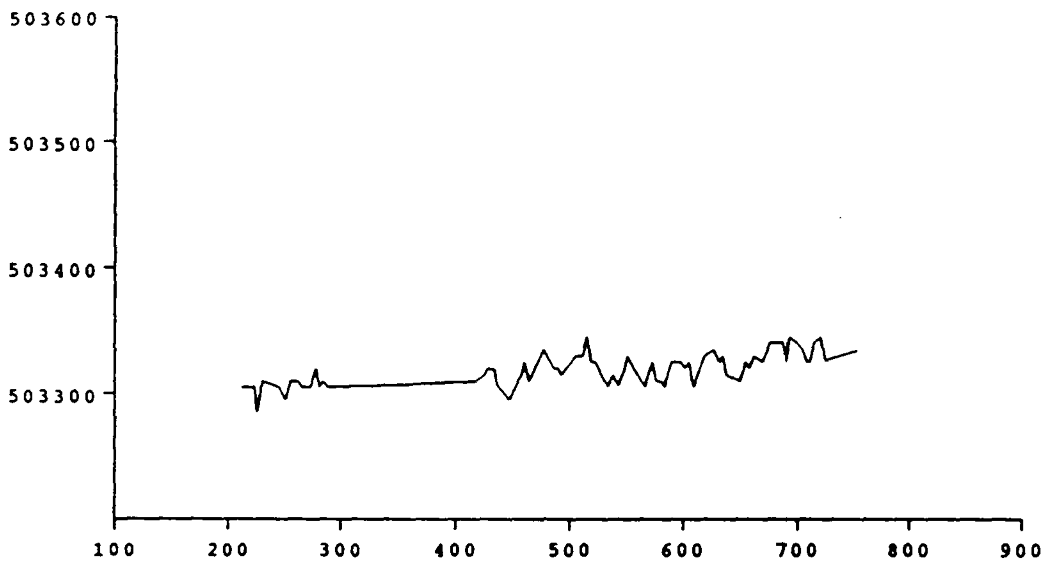

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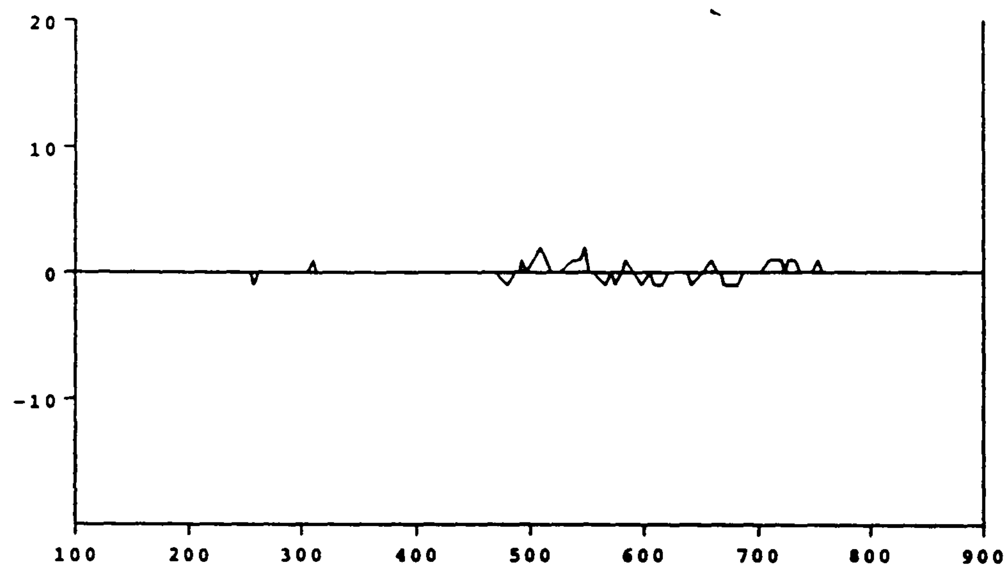

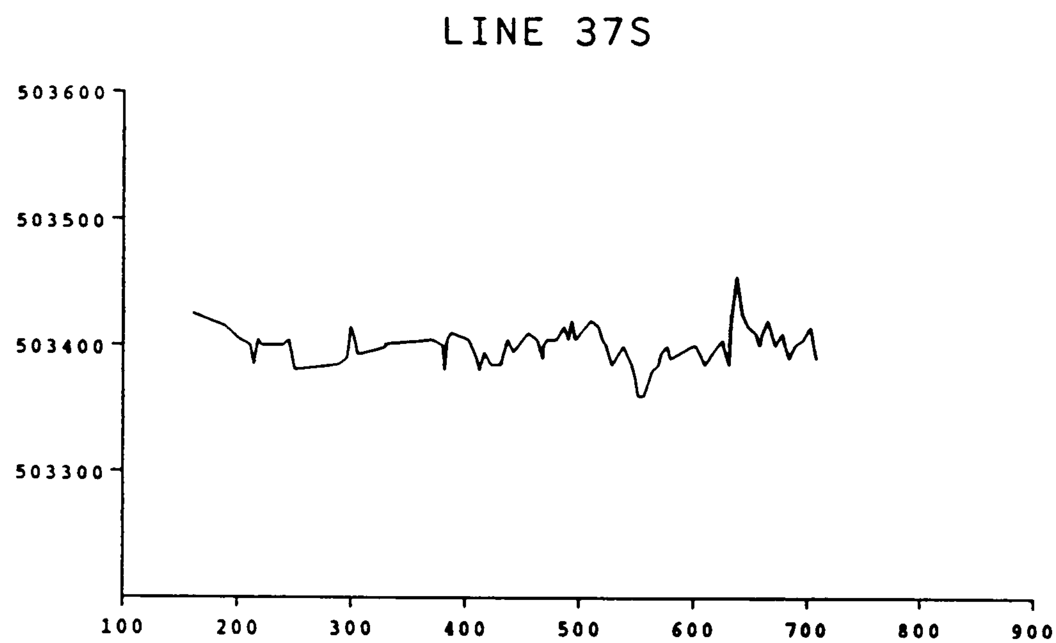
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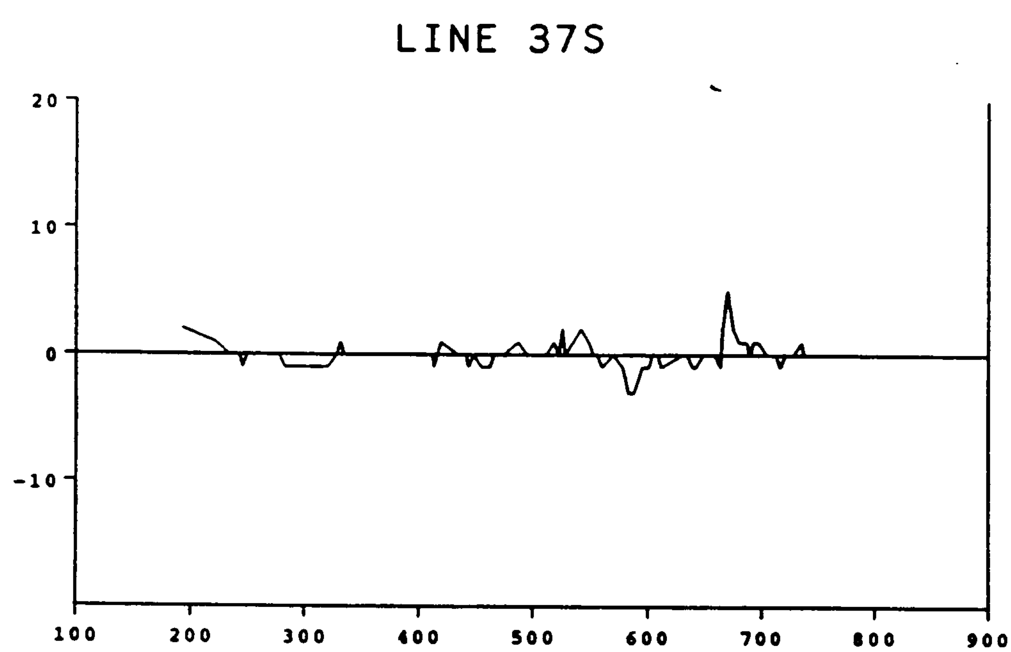
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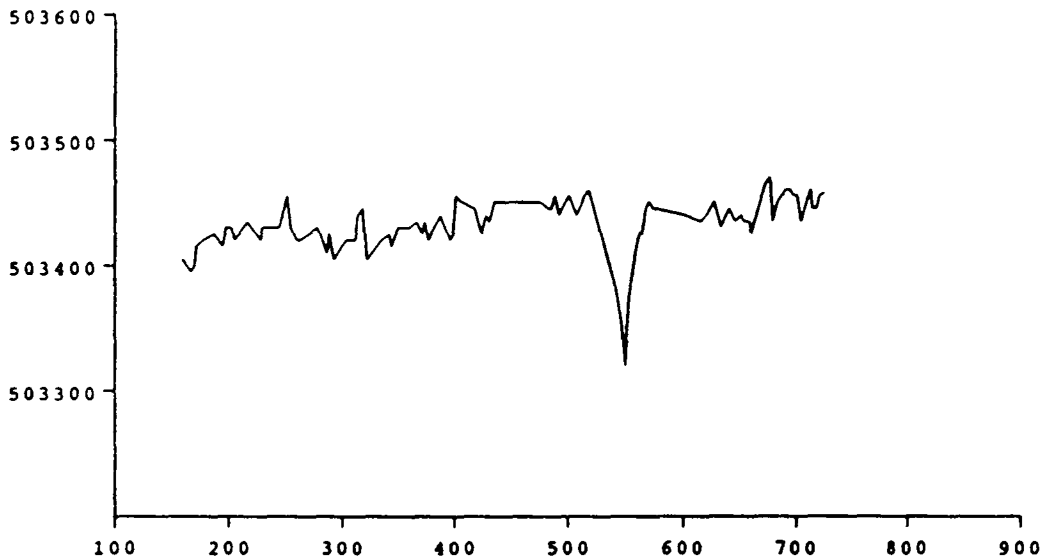

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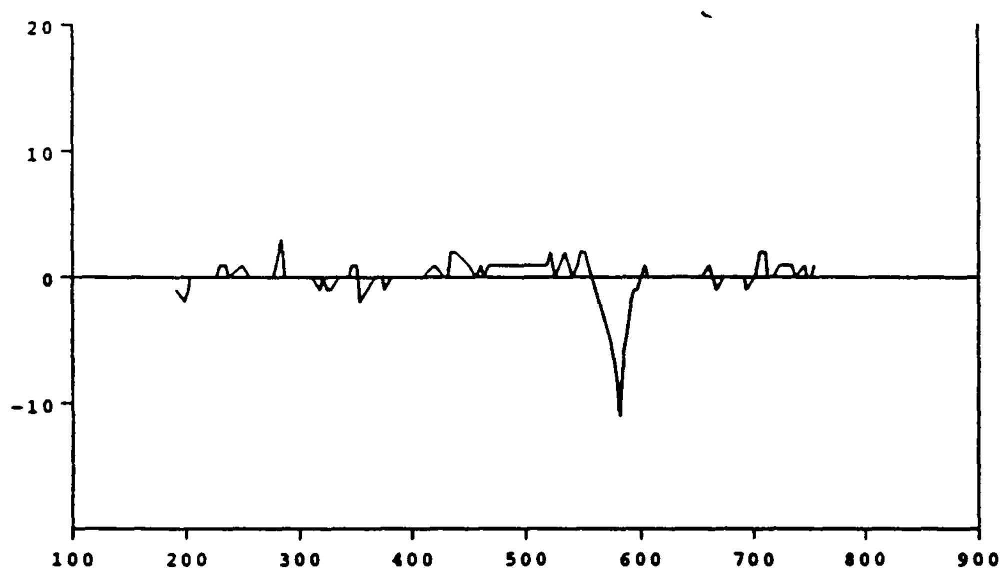

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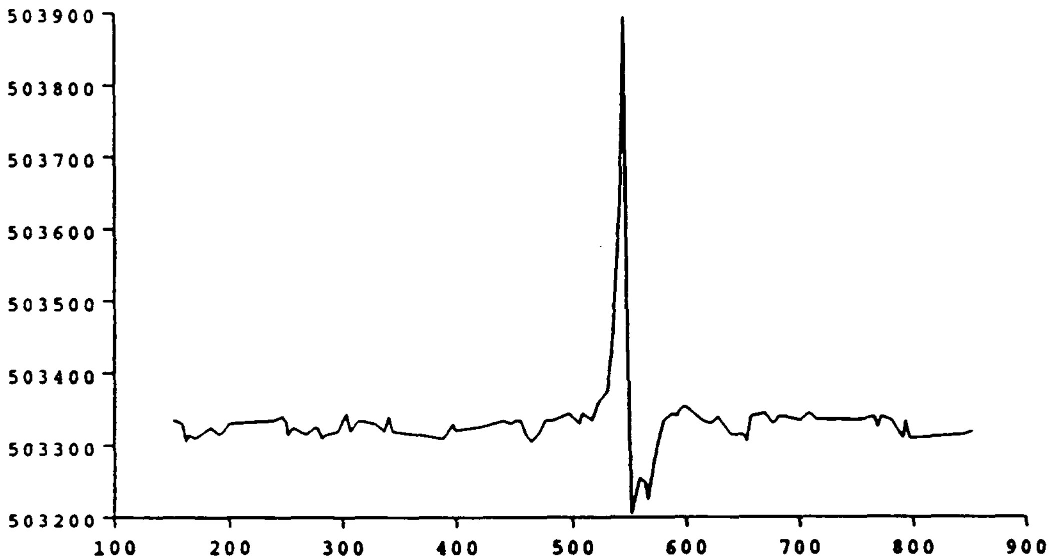

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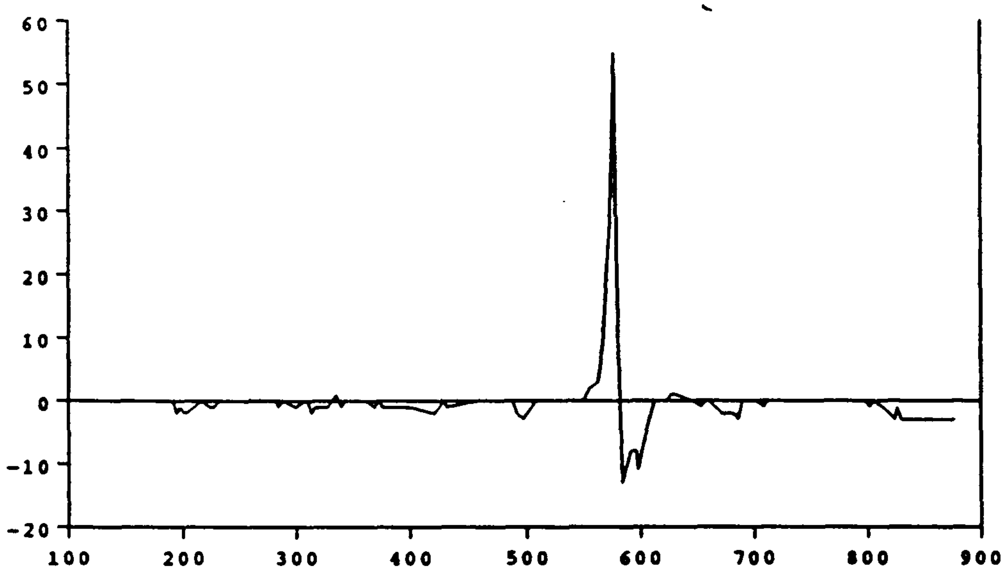

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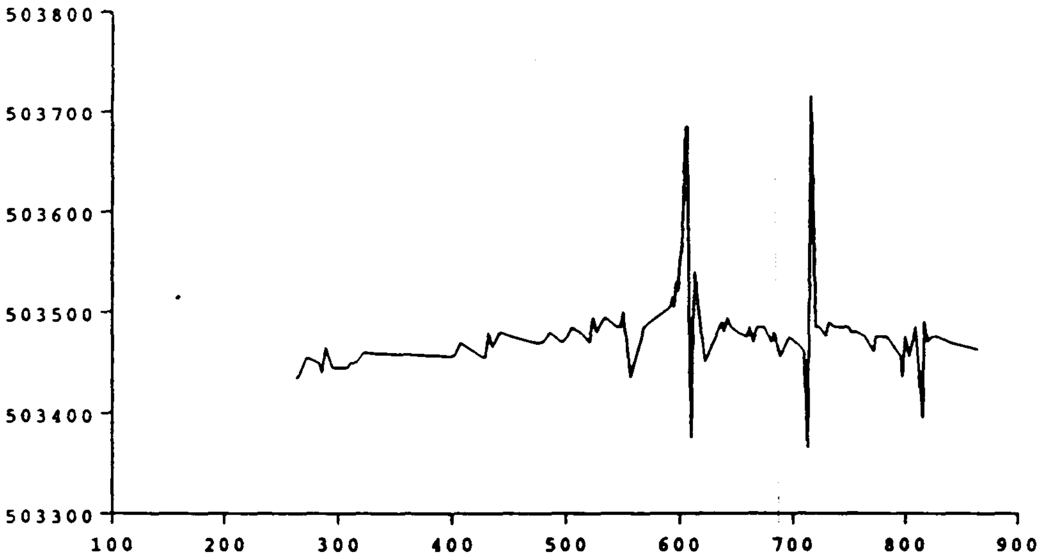

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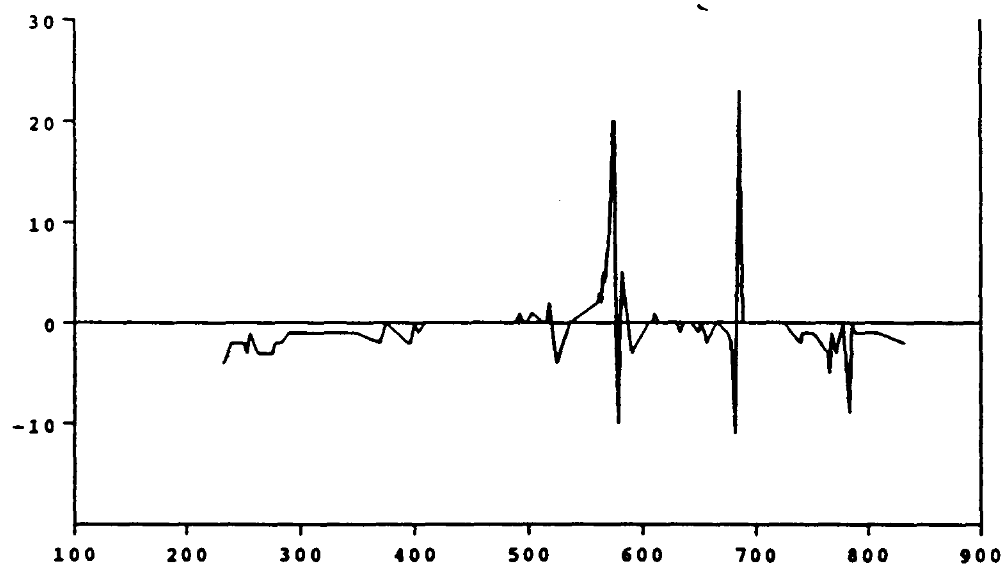

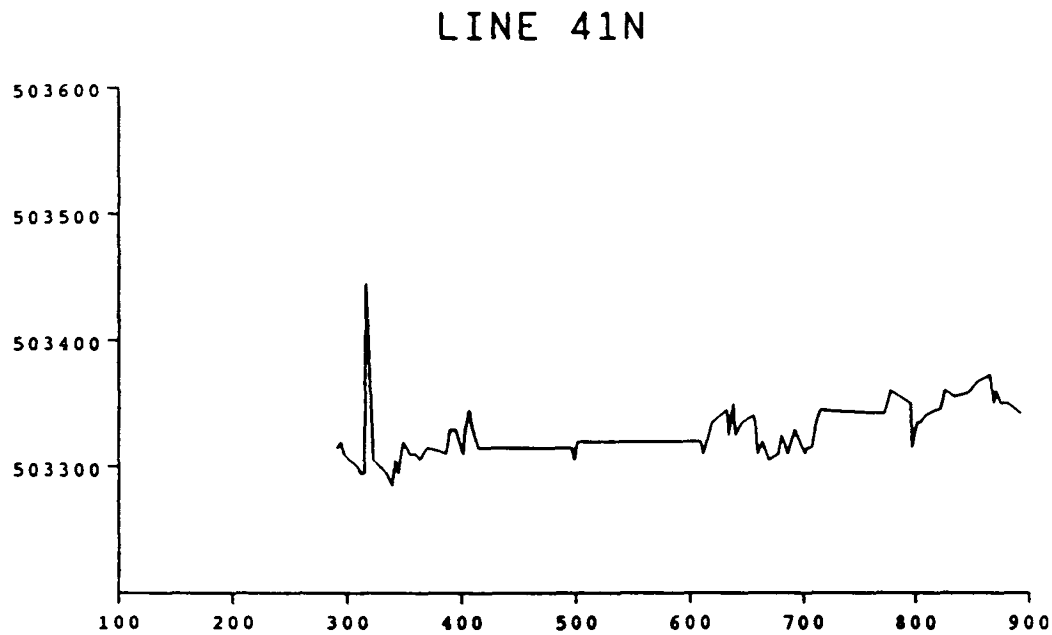
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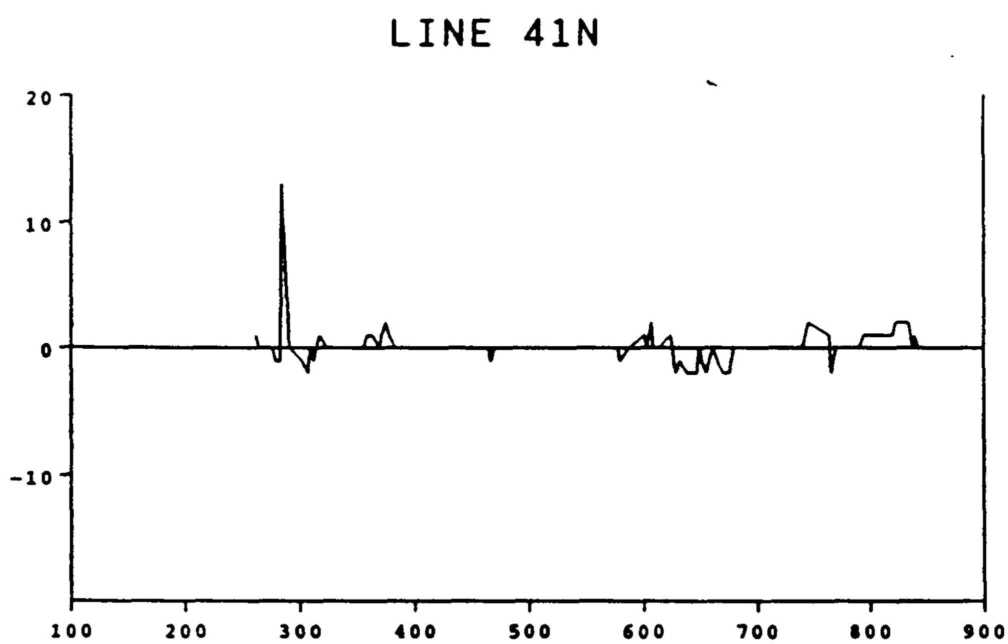
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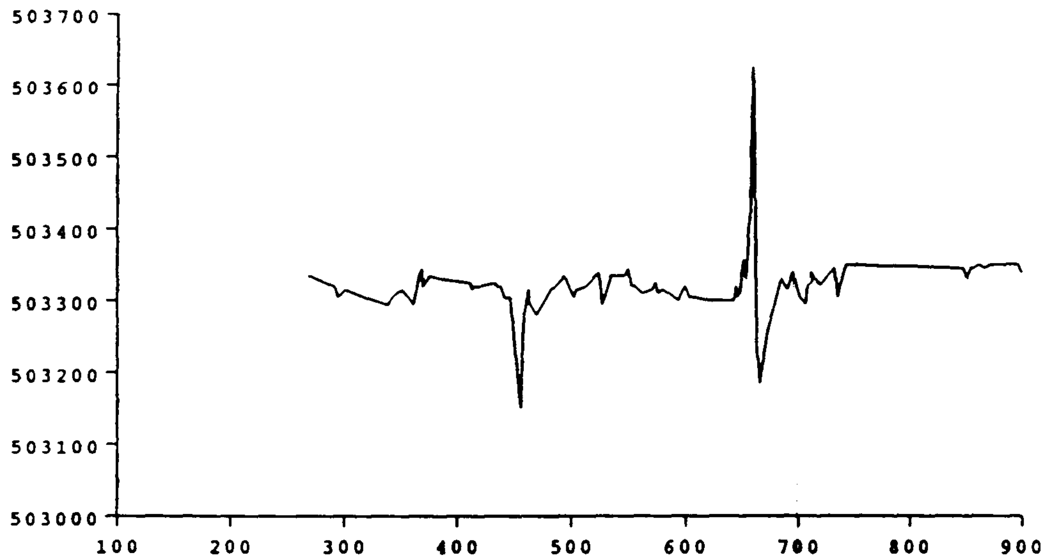

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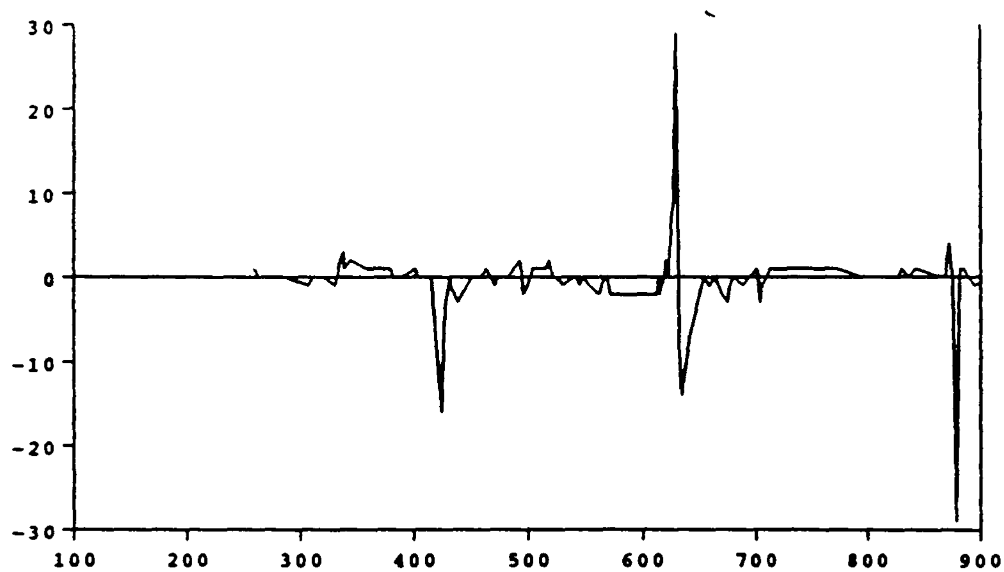

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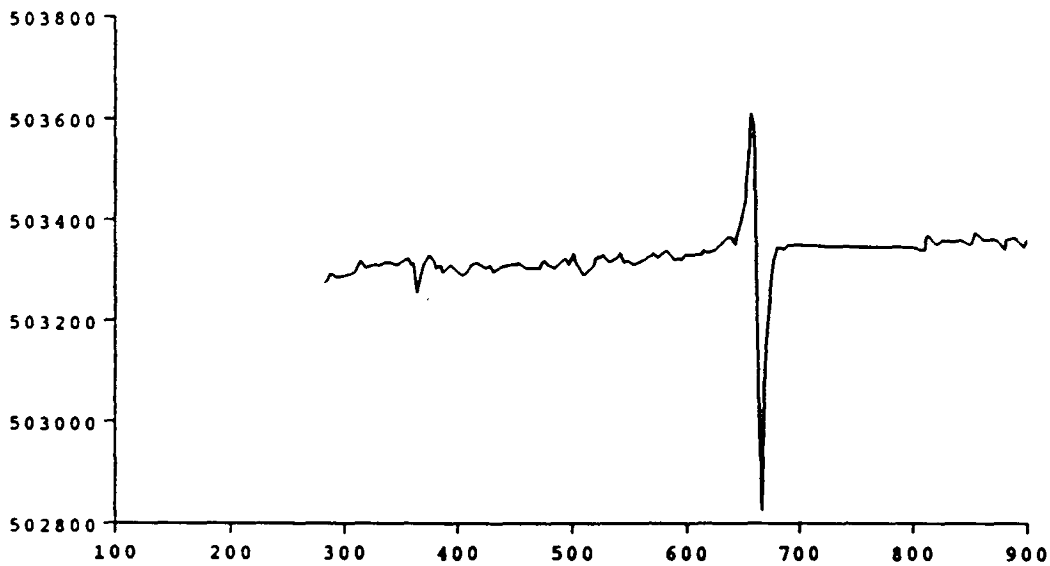

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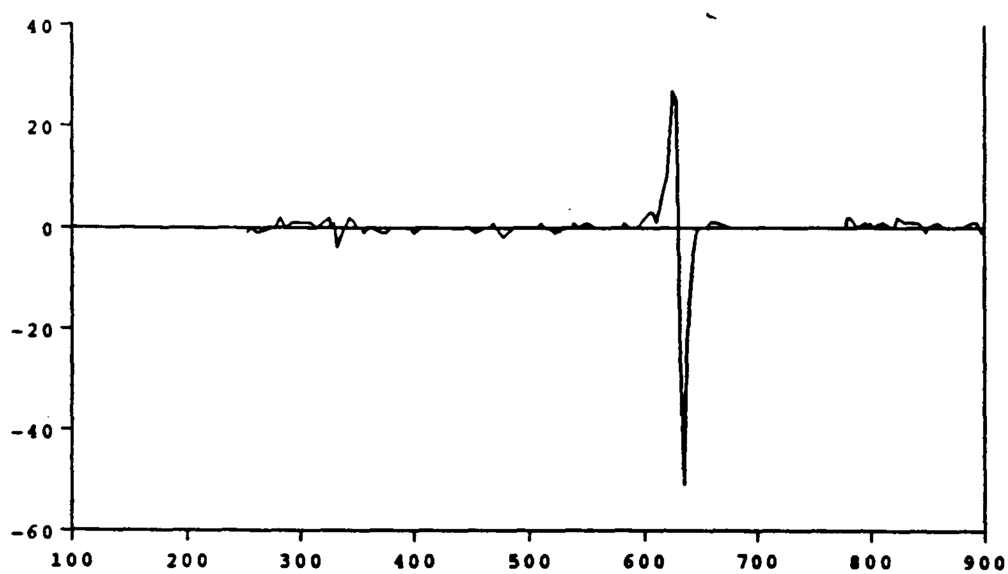

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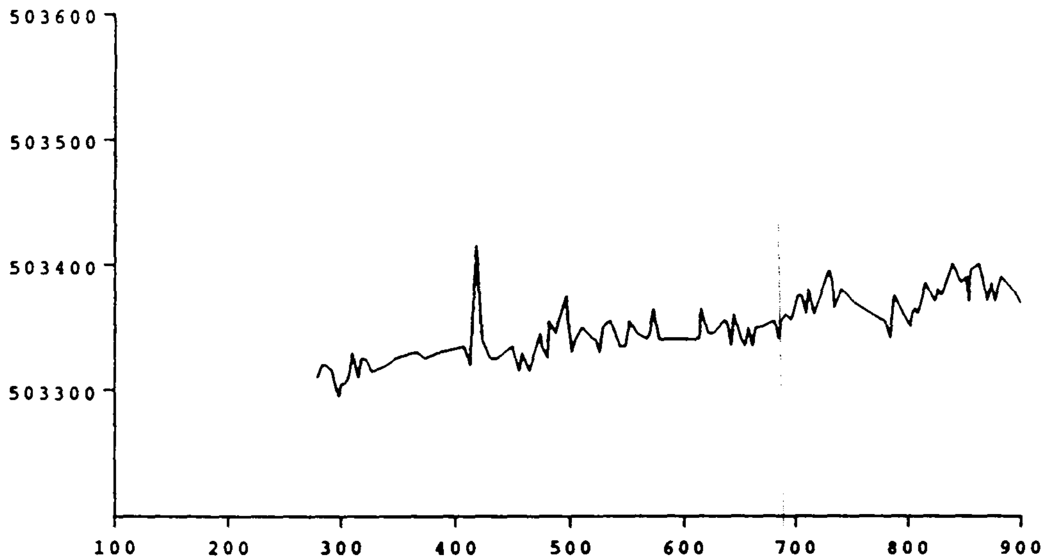

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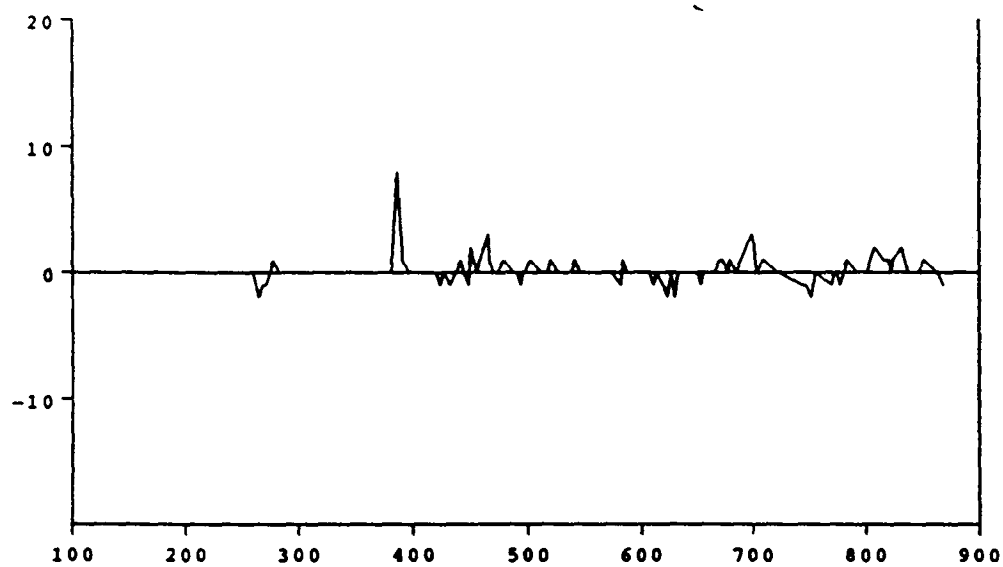

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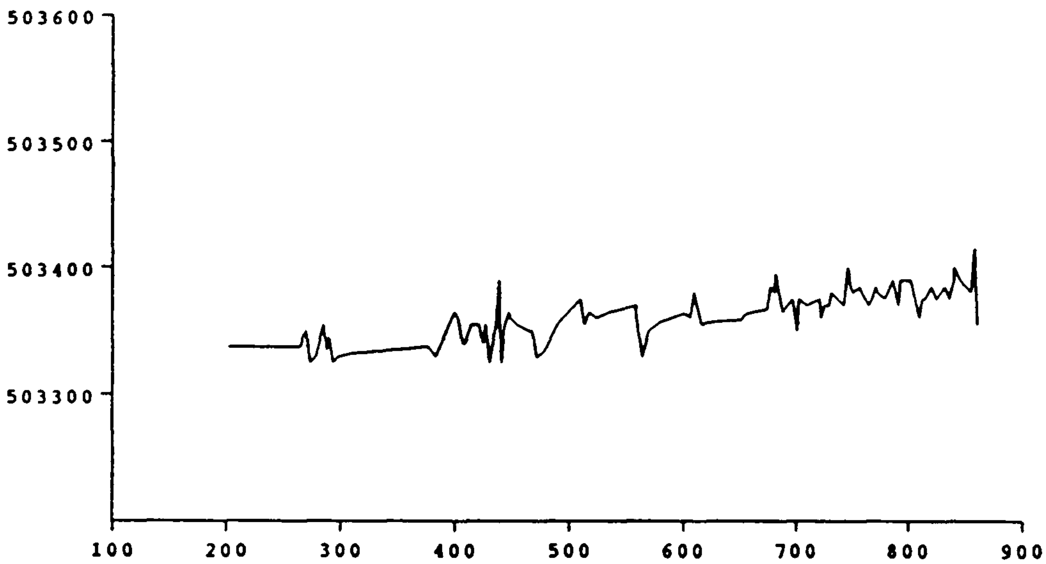

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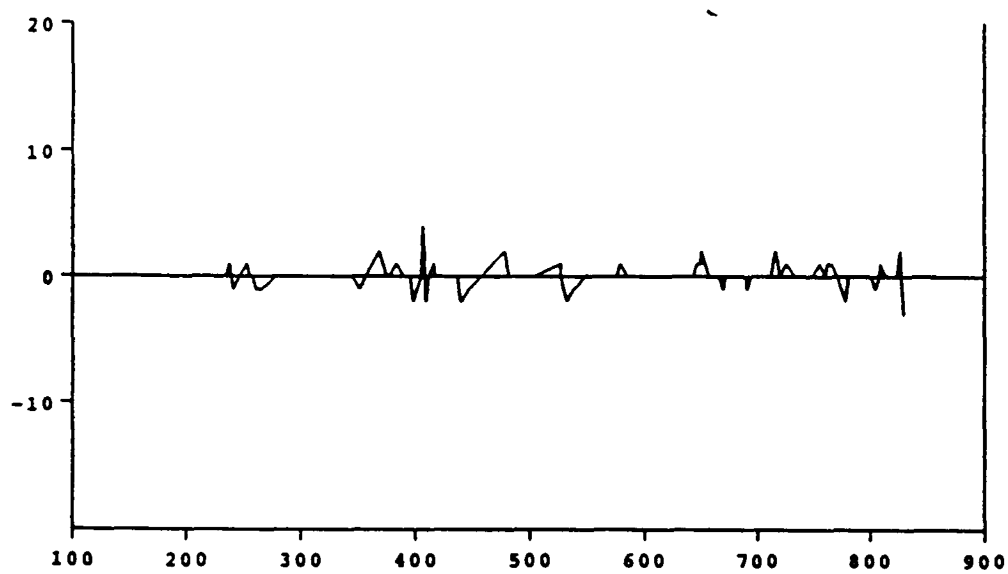

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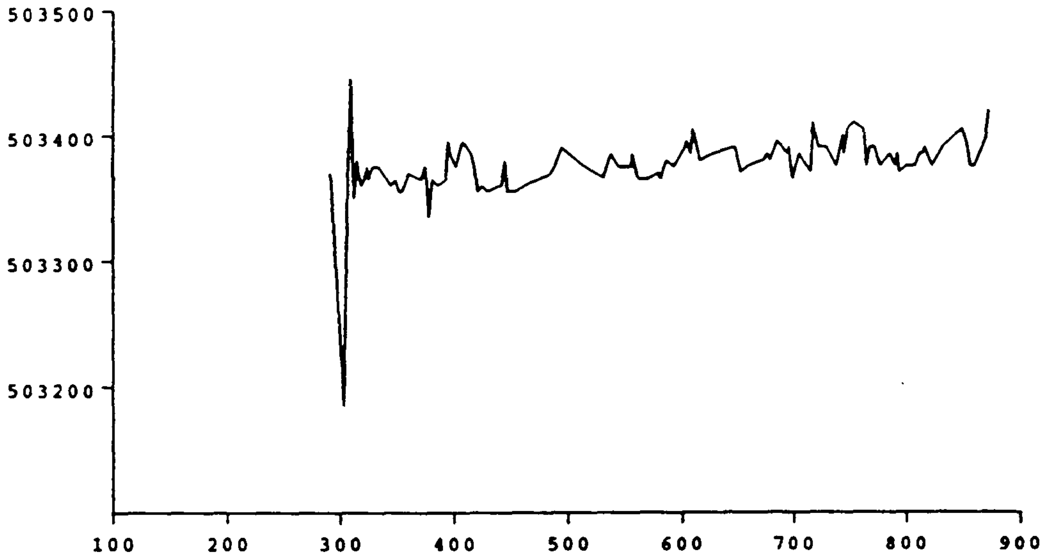

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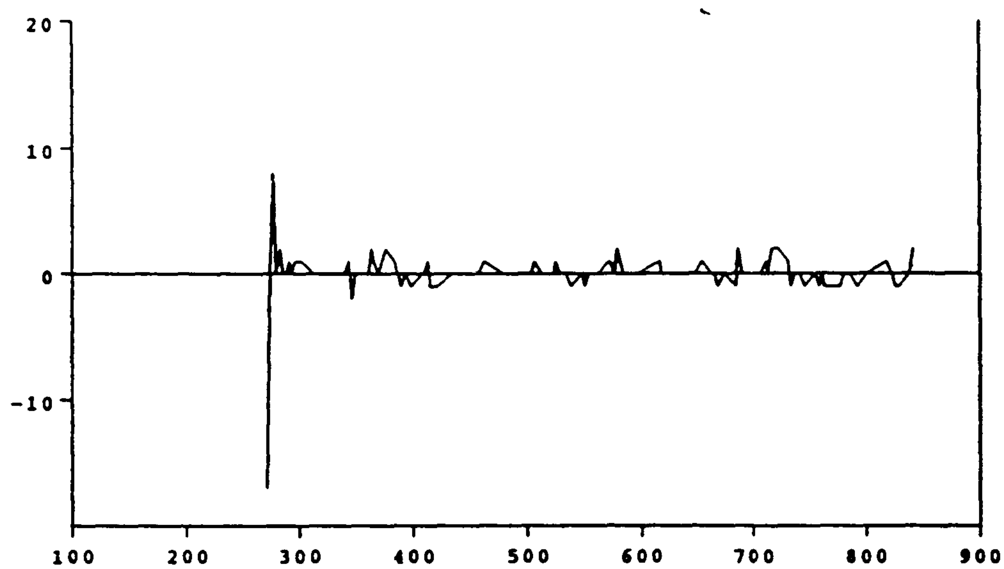

The Department of the Interior Mission

As the Nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally owned public lands and natural resources. This includes fostering sound use of our land and water resources; protecting our fish, wildlife, and biological diversity; preserving the environmental and cultural values of our national parks and historical places; and providing for the enjoyment of life through outdoor recreation. The Department assesses our energy and mineral resources and works to ensure that their development is in the best interests of all our people by encouraging stewardship and citizen participation in their care. The Department also has a major responsibility for American Indian reservation communities and for people who live in island territories under U.S. administration.

The Minerals Management Service Mission

As a bureau of the Department of the Interior, the Minerals Management Service's (MMS) primary responsibilities are to manage the mineral resources located on the Nation's Outer Continental Shelf (OCS), collect revenue from the Federal OCS and onshore Federal and Indian lands, and distribute those revenues.

Moreover, in working to meet its responsibilities, the **Offshore Minerals Management Program** administers the OCS competitive leasing program and oversees the safe and environmentally sound exploration and production of our Nation's offshore natural gas, oil and other mineral resources. The MMS **Minerals Revenue Management** meets its responsibilities by ensuring the efficient, timely and accurate collection and disbursement of revenue from mineral leasing and production due to Indian tribes and allottees, States and the U.S. Treasury.

The MMS strives to fulfill its responsibilities through the general guiding principles of: (1) being responsive to the public's concerns and interests by maintaining a dialogue with all potentially affected parties and (2) carrying out its programs with an emphasis on working to enhance the quality of life for all Americans by lending MMS assistance and expertise to economic development and environmental protection.