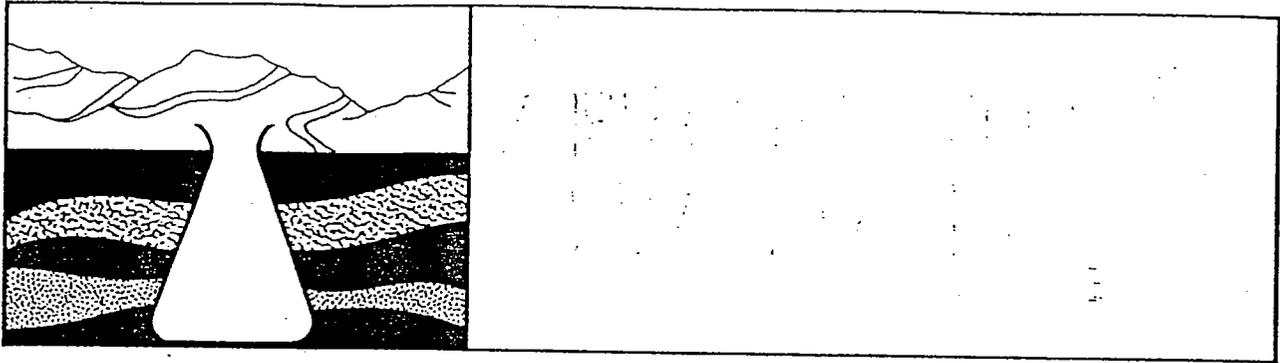


Appendix D      Material Safety Data Sheets (MSDS)



MC26

AEROFROTH<sup>®</sup>71A Frother, a new mixture of high molecular weight alcohols, is similar in composition and frothing properties to AEROFROTH 71 Frother which it replaces.

### APPLICATION

Being water-insoluble, AEROFROTH 71A is fed to the flotation circuit full strength. For a more stable, persistent froth, use AEROFROTH 71A in conjunction with pine oil or glycol frothers such as AEROFROTH 65 Frother. It is miscible in all proportions with each of these.

### RECOMMENDATIONS

AEROFROTH 71A Frother is recommended for sulfide and non-metallic flotation in both alkaline and acid circuits. It generates a lively, selective froth.

### TREATMENT LEVEL

Dosage rates are usually in the range 5 to 50 grams/metric ton (0.01 to 0.10 lb/ton).

### TYPICAL PROPERTIES

Appearance	Colorless to light yellow liquid
Specific gravity (20° C)	0.89 to 0.90
Viscosity, Brookfield (20° C)	10 cps
Flashpoint	
Tag Open Cup	62° C (144° F)
Pensky-Martens Closed Cup	57° C (134° F)
Boiling range	145° to 227° C (293° to 440° F)
Freezing point	below -76° C (-60° F)

### ENVIRONMENTAL PROPERTIES

Biochemical oxygen demand (BOD)	
5 days	1,049g O <sub>2</sub> /1000g frother
20 days	1,980g O <sub>2</sub> /1000g frother
Chemical oxygen demand (COD)	2,368g O <sub>2</sub> /1000g frother

AEROFROTH 71A Frother is a stable, non-corrosive material which can be handled and stored in iron or carbon steel equipment.

200 liter (55 gallon) non-returnable steel drums.  
Net—177 kg (390 lb); Average Tare—22 kg (48 lb); Average Gross—199 kg (438 lb); Cubage—10.715 cu. ft.

Follow precautions for a Class II combustible liquid. Keep away from heat and open flames.

In case of contact, immediately flush eyes with plenty of water for at least 15 minutes. Call a physician. If product is spilled, remove sources of ignition. Cover with some absorbent material; sweep up and place in a waste disposal container. Flush area with water.

Good water management for you and for our environment depends on using the best products and the latest technology in a totally balanced program. At Cyanamid, we offer a full system of water treatment products designed to meet your needs. Your Cyanamid Sales Representative stands ready to offer information and assistance in using this product and helping you achieve our common goal — clean water.

#### IMPORTANT NOTICE

The information and statements herein are believed to be reliable but are not to be construed as a warranty or representation for which we assume legal responsibility. Users should undertake sufficient verification and testing to determine the suitability for their own particular purpose of any information or products referred to herein. NO WARRANTY OF FITNESS FOR A PARTICULAR PURPOSE IS MADE.

Nothing herein is to be taken as permission, inducement or recommendation to practice any patented invention without a license.

# Material Safety Data Sheet

NUMBER

1067

(Approved by U.S. Department of Labor as "essentially similar" to Form LSB-005-4)

SECTION I IDENTIFICATION OF PRODUCT	
MANUFACTURER'S NAME	AMERICAN CYANAMID COMPANY
EMERGENCY TELEPHONE NO.	(201) 835-3100
ADDRESS	Wayne, New Jersey 07470
TRADE NAME AND SYNONYMS	AEROFROTH <sup>®</sup> 71-A Frother
CHEMICAL NAME AND SYNONYMS	Mixture of aliphatic alcohols
CHEMICAL FAMILY	Alcohols
MOLECULAR FORMULA	Mixture

SECTION II HAZARDOUS COMPONENTS OF MIXTURES		
COMPONENT	%	THRESHOLD LIMIT VALUE (UNITS)
Cyclohexanol	23.9	50 parts per million

SECTION III PHYSICAL DATA	
APPEARANCE AND ODOR	Light-brown liquid; sweet odor.
BOILING POINT (DEGREES FAHRENHEIT)	293-440
SPECIFIC GRAVITY (WATER = 1)	0.895
VAPOR PRESSURE (MM. OF MERCURY)	Not available
PERCENT VOLATILE (BY VOLUME)	10
VAPOR DENSITY (AIR = 1)	Not available
EVAPORATION RATE (BUTYL ACETATE = 1)	<1
SOLUBILITY IN WATER	Partial
EVAPORATION RATE (ETHYL ETHER = 1)	Not available

SECTION IV FIRE AND EXPLOSION HAZARD DATA	
FLASH POINT (SPECIFY METHOD) (DEGREES FAHRENHEIT)	134 Closed Cup
FLAMMABLE LIMITS (PERCENT BY VOLUME)	LOWER 1.2 (n-pentanol) UPPER 10-0
FIRE-EXTINGUISHING MEDIA	"Alcohol" foam, CO <sub>2</sub> , dry chemical, or water spray.
SPECIAL FIRE-FIGHTING PROCEDURES	Use water-spray to keep containers cool.
UNUSUAL FIRE AND EXPLOSION HAZARDS	Will form explosive vapor-air mixtures above 120 F.

THIS INFORMATION IS GIVEN WITHOUT A WARRANTY OR REPRESENTATION. WE DO NOT ASSUME ANY LEGAL RESPONSIBILITY FOR SAME. NOR DO WE GIVE PERMISSION, INDUCEMENT, OR RECOMMENDATION TO PRACTICE ANY PATENTED INVENTION WITHOUT A LICENSE. IT IS OFFERED SOLELY FOR YOUR CONSIDERATION, INVESTIGATION AND VERIFICATION. BEFORE USING ANY PRODUCT READ ITS LABEL.

READ THE BACK



# Material Safety Data Sheet

NUMBER

1067

(Approved by U.S. Department of Labor as "essentially similar" to Form LSB-005-4)

SECTION I IDENTIFICATION OF PRODUCT			
MANUFACTURER'S NAME	AMERICAN CYANAMID COMPANY		EMERGENCY TELEPHONE NO. (201) 835-3100
ADDRESS	Wayne, New Jersey 07470		
TRADE NAME AND SYNONYMS	AEROFROTH <sup>®</sup> 71-A Frother		
CHEMICAL NAME AND SYNONYMS	Mixture of aliphatic alcohols		
CHEMICAL FAMILY	Alcohols	MOLECULAR FORMULA	Mixture

SECTION II HAZARDOUS COMPONENTS OF MIXTURES			
COMPONENT	%	THRESHOLD LIMIT VALUE (UNITS)	
Cyclohexanol	23.9	50 parts per million	

SECTION III PHYSICAL DATA			
APPEARANCE AND ODOR	Light-brown liquid; sweet odor.		
BOILING POINT (DEGREES FAHRENHEIT)	293-440	SPECIFIC GRAVITY (WATER = 1)	0.895
VAPOR PRESSURE (MM. OF MERCURY)	Not available	PERCENT VOLATILE (BY VOLUME)	10
VAPOR DENSITY (AIR = 1)	Not available	EVAPORATION RATE (BUTYL ACETATE = 1)	<1
SOLUBILITY IN WATER	Partial	EVAPORATION RATE (ETHYL ETHER = 1)	Not available

SECTION IV. FIRE AND EXPLOSION HAZARD DATA			
FLASH POINT (SPECIFY METHOD) (DEGREES FAHRENHEIT)	134 Closed Cup	FLAMMABLE LIMITS (PERCENT BY VOLUME)	LOWER 1.2 (n-pentanol) UPPER 10-0
FIRE-EXTINGUISHING MEDIA	"Alcohol" foam, CO <sub>2</sub> , dry chemical, or water spray.		
SPECIAL FIRE-FIGHTING PROCEDURES	Use water-spray to keep containers cool.		
UNUSUAL FIRE AND EXPLOSION HAZARDS	Will form explosive vapor-air mixtures above 120 F.		

NA 8743-01 REV. 4-73 4-73

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READ THE BACK

### SECTION V HEALTH HAZARD DATA

THRESHOLD LIMIT VALUE

See Section II

EFFECTS OF OVEREXPOSURE

Liquid causes eye burns. Breathing excessive concentration of vapor may cause irritation of eyes, nose, and throat.

EMERGENCY AND FIRST AID PROCEDURES

In case of contact, immediately flush eyes with plenty of water for at least 15 minutes. Call a physician. In case of irritation of eyes or respiratory tract, remove from exposure.

### SECTION VI REACTIVITY DATA

STABILITY	UNSTABLE		CONDITIONS TO AVOID  None
	STABLE	X	
INCOMPATIBILITY (Materials to avoid) Bromides, oxidizing agents, organic acids.			
HAZARDOUS DECOMPOSITION PRODUCTS Thermal decomposition may produce carbon monoxide and/or carbon dioxide.			
HAZARDOUS POLYMERIZATION	MAY OCCUR.		CONDITIONS TO AVOID  None
	WILL NOT OCCUR	X	

### SECTION VII SPILL OR LEAK PROCEDURES

STEPS TO BE TAKEN IN CASE MATERIAL IS RELEASED OR SPILLED

Wear appropriate protective equipment and clothing. Remove sources of ignition. Cover with some inert absorbent material; sweep up and place in a waste disposal container. Flush area with water.

WASTE DISPOSAL METHOD

Disposal must be made in accordance with federal, state and local regulations.

### SECTION VIII SPECIAL PROTECTION INFORMATION

RESPIRATORY PROTECTION (Specify type) The need for respiratory protection should be determined by an industrial hygiene evaluation. If concentration exceeds the OSHA permissible level, wear respiratory protection approved by NIOSH appropriate to the degree of exposure.

VENTILATION	LOCAL EXHAUST Preferable	SPECIAL	None
	MECHANICAL (General) Acceptable	OTHER	None
PROTECTIVE GLOVES Not required		EYE PROTECTION Splashproof goggles	
OTHER PROTECTIVE EQUIPMENT Eyewash fountain			

### SECTION IX SPECIAL PRECAUTIONS

PRECAUTIONS TO BE TAKEN IN HANDLING AND STORING

Precautions for a Class II combustible liquid.

OTHER PRECAUTIONS

None

### SECTION X DATE AND SOURCE OF INFORMATION

DATE Revised  
December 27, 1976

NAME AND TITLE C. Boyd Shaffer, Ph.D.  
Director of Toxicology

SHEET NUMBER 1007

### SECTION V HEALTH HAZARD DATA

**THRESHOLD LIMIT VALUE** See Section II

**EFFECTS OF OVEREXPOSURE** Liquid causes eye burns. Breathing excessive concentration of vapor may cause irritation of eyes, nose, and throat.

**EMERGENCY AND FIRST AID PROCEDURES**  
In case of contact, immediately flush eyes with plenty of water for at least 15 minutes. Call a physician. In case of irritation of eyes or respiratory tract, remove from exposure.

### SECTION VI REACTIVITY DATA

<b>STABILITY</b>	<b>UNSTABLE</b>		<b>CONDITIONS TO AVOID</b>  None
	<b>STABLE</b>	X	
<b>INCOMPATIBILITY (Materials to avoid)</b> Bromides, oxidizing agents, organic acids.			
<b>HAZARDOUS DECOMPOSITION PRODUCTS</b> Thermal decomposition may produce carbon monoxide and/or carbon dioxide.			
<b>HAZARDOUS POLYMERIZATION</b>	<b>MAY OCCUR</b>		<b>CONDITIONS TO AVOID</b>  None
	<b>WILL NOT OCCUR</b>	X	

### SECTION VII SPILL OR LEAK PROCEDURES

**STEPS TO BE TAKEN IN CASE MATERIAL IS RELEASED OR SPILLED**  
Wear appropriate protective equipment and clothing. Remove sources of ignition. Cover with some inert absorbent material; sweep up and place in a waste disposal container. Flush area with water.

**WASTE DISPOSAL METHOD**  
Disposal must be made in accordance with federal, state and local regulations.

### SECTION VIII SPECIAL PROTECTION INFORMATION

**RESPIRATORY PROTECTION (Specify type)** The need for respiratory protection should be determined by an industrial hygiene evaluation. If concentration exceeds the OSHA permissible level, wear respiratory protection approved by NIOSH appropriate to the degree of exposure.

<b>VENTILATION</b>	LOCAL EXHAUST Preferable	SPECIAL	None
	MECHANICAL (General) Acceptable	OTHER	None
<b>PROTECTIVE GLOVES</b> Not required		<b>EYE PROTECTION</b> Splashproof goggles	
<b>OTHER PROTECTIVE EQUIPMENT</b> Eyewash fountain			

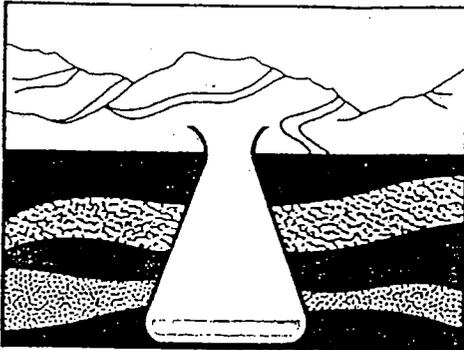
### SECTION IX SPECIAL PRECAUTIONS

**PRECAUTIONS TO BE TAKEN IN HANDLING AND STORING**  
Precautions for a Class II combustible liquid.

**OTHER PRECAUTIONS**  
None

### SECTION X DATE AND SOURCE OF INFORMATION

DATE Revised December 27, 1976	NAME AND TITLE C. Boyd Shaffer, Ph.D. Director of Toxicology	SHEET NUMBER 1067
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# Aqueous AEROFLOAT<sup>®</sup> sodium promoter

MC 4

Sodium AEROFLOAT Promoter is an aqueous solution of sodium diethyldithiophosphate, used in the flotation of copper and zinc sulfides in the presence of pyrite and other iron sulfides.

## ADVANTAGES

**Aqueous solution** — improved handling, mixing and feeding characteristics. Unlike the dry AEROFLOAT Promoters, it contains no sodium carbonate, thereby preventing problems with sludge formation, when dilution water contains calcium and magnesium ions. Fast acting, usually requiring little or no conditioning.

## APPLICATION

Sodium AEROFLOAT Promoter as sold can be fed directly, or can be diluted to any desired strength. For ease of metering, it is usually diluted 5 to 20 times. This product has practically no frothing properties.

## PRINCIPAL USES

Flotation of copper, silver and activated zinc sulfides, particularly when selectivity against pyrite and other iron sulfides is desired. This product can be used in conjunction with xanthates and Cyanamid's 400 Series Promoters.

## TREATMENT LEVEL

Dosage rates are usually in the range 0.01-0.20 lb. Promoter/ton (5 to 100 grams/metric ton). For maximum selectivity stage addition can be considered.

## TYPICAL PROPERTIES

Appearance	Colorless to yellow liquid
pH	11.8
Specific gravity	
0°C.	1.226
30°C.	1.203
Viscosity, Brookfield (centipoise)	
0°C.	22.2
30°C.	6.1
Boiling point (°C.)	103
Freezing point (°C.)	
Crystallization begins	-4
Pourable slurry forms	-9
Product solidifies	-13
Freeze-thaw stability	Good

## ENVIRONMENTAL PROPERTIES

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BOD <sub>5</sub>	(g. BOD/g. promoter)	0.02
COD <sub>5</sub>	(g. COD/g. promoter)	0.60

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## HANDLING

The aqueous AEROFLOATS are corrosive to a greater or lesser extent to most metals. It is recommended that storage of either the **strong** or **diluted** solution of the product be in 316 stainless steel or in mild steel tanks equipped with a phenolic liner. Plastic or phenolic type pipe is suitable for transfer of the product in either the strong or diluted form.

## TOXICITY

Prolonged contact of the strong solution with the skin should be avoided. Where contact has been made, water in copious quantities should be used to cleanse. Alkali burns of the skin may result if protective gloves and goggles or face shields are not used during handling. In case of eye contact, wash eye in eye bath immediately for 15 minutes. If taken internally, vomiting should be induced, although the material is considered to be only mildly toxic.

## SHIPPING

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50/55 gallon non-returnable steel drums. Net — 500 lbs., Gross — 573 lbs., F.O.B. Warners, N.J.

## TECHNICAL SERVICE

Technical service and information for making the best use of this product are available through your Cyanamid representative.

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## IMPORTANT NOTICE

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Nothing herein is to be taken as permission, inducement or recommendation to practice any patented invention without a license.



MSDS NO. 0415-01  
 CAS NO.  
 DATE: 06/13/83

# MATERIAL SAFETY DATA

## PRODUCT IDENTIFICATION

TRADEMARK: **AEROFLOAT® Sodium Promoter, Aqueous**  
 SYNONYMS: None  
 CHEMICAL FAMILY: Dithiophosphate Salt  
 MOLECULAR FORMULA: C4H10O2PNaS2  
 MOLECULAR WGT.: 208.2

## WARNING

CAUSES BURNS OF EYES AND SKIN

## HAZARDOUS INGREDIENTS

COMPONENT	CAS. NO.	%	TWA/CEILING	REFERENCE
No Permissible Exposure Limits (PEL), have been established by OSHA				

## NFPA HAZARD RATING

Not Established

## HEALTH HAZARD INFORMATION

### EFFECTS OF OVEREXPOSURE:

Aerofloat, Sodium Promoter, Aqueous is an extremely caustic and corrosive material. It will cause necrosis of skin upon dermal exposure and can cause irreversible eye damage. Aerofloat, Sodium Promoter, Aqueous reacts with acid to liberate toxic and flammable hydrogen sulfide gas. This gas causes severe eye and respiratory tract irritation, rapid development of coma and respiratory failure. While hydrogen sulfide has a rotten-egg odor, some people are unable to smell the gas. Hydrogen sulfide also deadens the sense of smell so that once smelled, it is no longer detected.

### FIRST AID:

In case of skin contact, remove contaminated clothing without delay. Flush skin thoroughly with water. Do not reuse clothing without laundering. In case of eye contact, immediately irrigate with plenty of water for 15 minutes. Obtain medical attention if irritation persists. If vapor of AEROFLOAT Sodium Promoter, Aqueous is inhaled, remove from exposure. Administer oxygen if there is difficulty in breathing.

EMERGENCY PHONE: 201/835-3100

**EXPOSURE  
CONTROL METHODS**

Engineering controls are not usually necessary, if good hygiene practices are strictly followed. Where concentrations are below the PEL, no respiratory protection is required. For spills or leaks, such protection may be necessary. Where exposures exceed PEL, use respirator approved by NIOSH for the material and level of exposure. See "GUIDE TO INDUSTRIAL RESPIRATORY PROTECTION" (NIOSH). Material causes eye or skin burns or severe irritation on contact. A full facepiece respirator will provide eye and face protection. Wear the following as necessary to prevent skin contact; work pants, long sleeve work shirt, impervious gloves, and impervious apron. For operations where eye or face contact can occur wear respiratory protection outlined above, (full facepiece) or chemical splash proof goggles and a faceshield. Provide eyewash fountain and safety shower in close proximity to points of potential exposure.

**FIRE AND  
 EXPLOSION  
 HAZARD  
 INFORMATION**

FLASH POINT: METHOD:	> 200 F ( > 93.3 C) Setaflash Closed Cup
FLAMMABLE LIMITS (% BY VOL):	Not Available
AUTOIGNITION TEMP:	Not Available
DECOMPOSITION TEMP:	212 F (100 C)
FIRE FIGHTING:	Use water, carbon dioxide or dry chemical to extinguish fires. Wear self-contained, positive pressure breathing apparatus and full firefighting protective clothing. See Exposure Control Methods for special protective clothing. Do not flush to sewer which could contain acid. Material reacts with acid to liberate toxic and flammable hydrogen sulfide gas.

**REACTIVITY DATA**

STABILITY:	Stable
CONDITIONS TO AVOID:	None known
POLYMERIZATION: CONDITIONS TO AVOID:	Will Not Occur None known
INCOMPATIBLE MATERIALS:	Product reacts with acids to liberate gaseous hydrogen sulfide.
HAZARDOUS DECOMPOSITION PRODUCTS:	Thermal decomposition or combustion (of dried solids) may produce carbon monoxide, carbon dioxide, sulfur oxides, hydrogen sulfide and/or oxides of phosphorus.

**PHYSICAL  
 PROPERTIES**

APPEARANCE AND ODOR:	Light straw to amber colored liquid; characteristic odor
BOILING POINT:	219-227 F; 104-108 C
MELTING POINT:	Not Applicable
VAPOR PRESSURE:	Similar to water
SPECIFIC GRAVITY:	Similar to water
VAPOR DENSITY:	Similar to water
% VOLATILE (BY VOL):	∞ 50 (water)
OCTANOL/H <sub>2</sub> O PARTITION COEF.:	Kow < 10
pH:	11.0 (minimum)
SATURATION IN AIR (BY VOL):	Not Available
EVAPORATION RATE:	Not Available
SOLUBILITY IN WATER:	Complete

**SPILL OR LEAK PROCEDURES**

**STEPS TO BE TAKEN IN CASE MATERIAL IS RELEASED OR SPILLED:**

In addition to the protective clothing/equipment in Exposure Control Methods, wear rain suit and impervious boots. Cover with some inert absorbent material; sweep up and place in a waste disposal container. Flush area with water. Do not flush to sewers.

**WASTE DISPOSAL**

Disposal must be made in accordance with applicable governmental regulations.

**SPECIAL PRECAUTIONS**

**HANDLING AND STORAGE/OTHER:**

Do not mix with any other chemicals without specific instructions from the manufacturer. AEROFLOAT Sodium Promoter should not be mixed with acids since evolution of toxic and explosive hydrogen sulfide gas could result.

*Marvin A. Friedman*

Marvin A. Friedman, Ph.D., Director of Toxicology and Product Safety

# AEROFLOAT<sup>®</sup> 242 Promoter

AEROFLOAT 242 promoter is a water-soluble salt of aryl dithiophosphoric acid with a small amount of a secondary promoter. It is a selective, active promoter with light frothing characteristics. AEROFLOAT 242 is especially useful where a fast-acting promoter is needed as in stage-addition during flotation or where no conditioning of promoter with pulp is possible.

## Typical Properties

Appearance	dark brown to black liquid
Odor	cresol
Specific gravity	1.13
Viscosity @ 25°C (77°F) Brookfield LVF, #2 spindle, 30 rpm	300-600 cps
Solubility in water	complete

## Environmental Properties

BOD <sub>5</sub>	102 mg/g
BOD <sub>20</sub>	126 mg/g
COD	1,910 mg/g

## Principal Uses

AEROFLOAT 242 is a water-soluble strong promoter that is widely used, particularly in the flotation of lead and copper minerals in the presence of sphalerite and iron sulfides, where selectivity against the latter sulfides is a serious problem. It is a fast-acting collector and performs effectively in stage-addition to flotation circuits.

AEROFLOAT 242 promoter is often preferred in zinc flotation circuits as well. In combination with AERO 404 promoter and/or xanthate, it produces excellent results in the flotation of gold ores.

## Treatment Level

Suggested dosage levels are in the range of 0.02 to 0.15 lb/ton (10 to 75 g/metric ton).

## Application

AEROFLOAT 242 promoter may be fed to the conditioner or the flotation circuit undiluted or as an aqueous solution of not less than 10%.

NOTE: When preparing aqueous solutions of this reagent, the proper procedure is to add water to the AEROFLOAT 242 promoter. Solution strength should not be permitted to drop below 10% prior to feeding.

## Toxicity

AEROFLOAT 242 promoter is corrosive to rabbit eyes and skin and contains cresylic acid. Cresylic acid is identified in Section 1910.1000 of the regulations to the U.S. Occupational Safety and Health Act. Employee exposure to cresylic acid as an air contaminant must be limited according to the provisions of this regulation.

## Caution

Do not mix with acids or acidic materials since evolution of poisonous and flammable hydrogen sulfide gas could result. These precautions do not, of course, apply to addition of this reagent to flotation pulps in the amounts normally used in flotation.

Flotation reagents should not be physically mixed with each other without first obtaining the assurance of the manufacturer or manufacturers that this would not present a safety hazard.

### **Storage & Handling**

Keep container closed and away from combustible material, heat and acids. If product is spilled, cover with some inert absorbent material; sweep up and place in a waste disposal container. Flush area with water. Do not flush to sewer which may contain acid.

AEROFLOAT 242 promoter should be stored in stainless steel, black iron, or plastic PVC. Do not use copper, brass, or soft rubber in feed or storage systems.

### **Shipping**

AEROFLOAT 242 promoter is shipped in 50/55 gallon (200 liter) steel drums, FOB Linden, N.J. For information on bulk delivery, contact your Cyanamid Sales Representative.

### **Technical Service**

Effective mill management depends on using the best products with the latest technology in totally balanced systems. Cyanamid offers a complete line of products: collectors, frothers, flocculants, depressants and filtering aids. Your Cyanamid Sales Representative is prepared with information and backed with technical service to aid you in applying our products.

### **Important Notice**

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MSDS NO. 0308-01  
CAS NO. -----  
DATE: 06/08/82

## MATERIAL SAFETY DATA

### PRODUCT IDENTIFICATION

TRADEMARK: **AEROFLOAT® 242 Promoter**  
SYNONYMS: None  
CHEMICAL FAMILY: Aryl phosphorodithioate  
MOLECULAR FORMULA: Mixture  
MOLECULAR WGT.: Mixture

### WARNING

CAUSES BURNS OF EYES AND SKIN  
HARMFUL IF INHALED

### HAZARDOUS INGREDIENTS

COMPONENT	CAS. NO.	%	TWA/CEILING	REFERENCE
Cresol	001319-77-3	10-15	5 ppm (skin)	OSHA

### NFPA HAZARD RATING

Not Established

### HEALTH HAZARD INFORMATION

#### EFFECTS OF OVEREXPOSURE:

Acute oral (rat) and acute dermal (rabbit) LD50 values for cresol are approximately 2.0 g/kg. Cresol is a strong tissue irritant and also can be corrosive. Liquid may be irritating and/or corrosive to the eyes or skin. Dermal exposure or inhalation of cresol may lead to central nervous system depression with confusion, depression and irregular, rapid breathing.

#### FIRST AID:

If AEROFLOAT 242 Promoter is ingested give 2 glasses of water or milk and induce vomiting. Never give anything by mouth or induce vomiting in an unconscious person. In case of skin contact, remove contaminated clothing without delay. Wear impervious gloves. Cleanse skin thoroughly with soap and water. Do not omit cleaning hair or under fingernails if contaminated. Do not reuse clothing without laundering. Do not reuse contaminated leatherware. In case of eye contact, immediately irrigate with plenty of water for 15 minutes. Refer to physician. If AEROFLOAT 242 Promoter is inhaled, remove from exposure. Administer oxygen if there is difficulty in breathing.

EMERGENCY PHONE: 201/835-3100

**EXPOSURE  
CONTROL METHODS**

Where a "closed system" is not used, good enclosure and local exhaust ventilation should be provided to minimize exposure. Shower after completion of workshift. Launder work clothing at end of workshift prior to reuse. Store street clothing separately from work clothing and protective equipment. Work clothing and shoes must not be taken home. Where exposures exceed PEL use respirator approved by NIOSH for the material and level of exposure. See "GUIDE TO INDUSTRIAL RESPIRATORY PROTECTION" (NIOSH). Material causes burns of eyes and skin on contact. A full facepiece respirator will provide eye and face protection. Provide eyewash fountain and safety shower in close proximity to points of potential exposure. Wear the following as necessary to prevent skin contact; impervious boots, impervious gloves, impervious aprons, work pants and long sleeve work shirt. For operations where eye or face contact can occur wear respiratory protection outlined above (full facepiece) or chemical splash proof goggles and a faceshield.

**FIRE AND  
EXPLOSION  
HAZARD  
INFORMATION**

FLASH POINT:	Not Available
FLAMMABLE LIMITS (% BY VOL):	Not Available
AUTOIGNITION TEMP:	Not Available
DECOMPOSITION TEMP:	Not Available
FIRE FIGHTING:	Use water, carbon dioxide or dry chemical to extinguish fires. Wear self-contained, positive pressure breathing apparatus and full firefighting protective clothing. See Exposure Control Methods for special protective clothing. Contact with acid liberates toxic and flammable hydrogen sulfide gas. Sulfur dioxide, hydrogen sulfide and/or ammonia may be formed under fire conditions. See Special Precautions. Do not flush to sewer which may contain acid.

**REACTIVITY DATA**

STABILITY:	Stable
CONDITIONS TO AVOID:	None known
POLYMERIZATION:	Will Not Occur
CONDITIONS TO AVOID:	None known
INCOMPATIBLE MATERIALS:	Contact with acid, or acidic material such as alum, liberates hydrogen sulfide. Strong mineral acids and/or strong oxidizers may cause exothermic reaction, Chlorosulfonic Acid.
HAZARDOUS DECOMPOSITION PRODUCTS:	Thermal decomposition or combustion may produce ammonia, carbon monoxide, carbon dioxide, sulfur oxides, hydrogen sulfide, phosphoric acid, oxides of phosphorus and/or oxides of nitrogen.

**PHYSICAL  
PROPERTIES**

APPEARANCE AND ODOR:	Dark brown to black liquid; cresol odor
BOILING POINT:	Not Available
MELTING POINT:	Not Available
VAPOR PRESSURE:	Not Available
SPECIFIC GRAVITY:	1.13
VAPOR DENSITY:	Not Available
% VOLATILE (BY VOL):	≈ 17.0
OCTANOL/H <sub>2</sub> O PARTITION COEF.:	Not Available
pH:	Not Available
SATURATION IN AIR (BY VOL):	Not Available
EVAPORATION RATE:	Not Available
SOLUBILITY IN WATER:	Complete

**SPILL OR LEAK PROCEDURES**

**STEPS TO BE TAKEN IN CASE MATERIAL IS RELEASED OR SPILLED:**

Where exposure level is not known, wear NIOSH approved positive pressure self-contained respirator. Where exposure level is known, wear NIOSH approved respirator suitable for level of exposure. Same protective clothing/equipment as in Exposure Control Methods. Cover spills with some inert absorbent material; sweep up and place in a waste disposal container. Flush area with water, do not flush to sewers which may contain acid.

**WASTE DISPOSAL**

Disposal must be made in accordance with applicable governmental regulations.

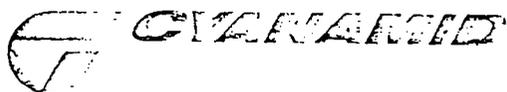
**SPECIAL PRECAUTIONS**

**HANDLING AND STORAGE/OTHER:**

Promoter should not be mixed with acids or aqueous solutions of acids since evolution of toxic and flammable hydrogen sulfide gas could result.

*Marvin A. Friedman*

Marvin A. Friedman, Ph.D., Director of Toxicology and Product Safety



# MATERIAL SAFETY DATA

MSDS NO. 0616-01  
CAS NO.  
DATE: 08/13/82

## PRODUCT IDENTIFICATION

TRADEMARK: **AERO® 3501 Promoter, Aqueous**  
SYNONYMS: None  
CHEMICAL FAMILY: Dithiophosphates  
MOLECULAR FORMULA: Mixture  
MOLECULAR WGT.: Mixture

## WARNING

CAUSES BURNS OF EYES AND SKIN

## HAZARDOUS INGREDIENTS

COMPONENT	CAS. NO.	%	TWA/CEILING	REFERENCE
No Permissible Exposure Limits (PEL), have been established by OSHA				

## NFPA HAZARD RATING

Not Established

## HEALTH HAZARD INFORMATION

EFFECTS OF OVEREXPOSURE: Liquid may cause marked eye irritation and marked skin irritation after prolonged or repeated contact. Contact with other tissues may cause irritation or damage.

FIRST AID: In case of skin contact, remove contaminated clothing without delay. Flush skin thoroughly with water. Do not reuse clothing without laundering. In case of eye contact, immediately irrigate with plenty of water for 15 minutes. Refer to a physician if irritation persists.

EMERGENCY PHONE: 201/835-3100

**EXPOSURE  
CONTROL METHODS**

Engineering controls are not usually necessary, if good hygiene practices are strictly followed. Where engineering controls are effective, respiratory protection is generally not required except during operations where exposures may occur. Use a NIOSH approved respirator recommended by an industrial hygienist after an evaluation of the operation. Material causes eye and skin burns or severe irritation on contact. A full facepiece respirator will provide eye and face protection. Wear the following as necessary to prevent skin contact; work pants, long sleeve work shirt, impervious gloves and impervious apron. For operations where eye or face contact can occur wear respiratory protection outlined above, (full facepiece) or chemical splash proof goggles and a faceshield. Provide eyewash fountain and safety shower in close proximity to points of potential exposure.

**FIRE AND  
 EXPLOSION  
 HAZARD  
 INFORMATION**

FLASH POINT:	Not Available
FLAMMABLE LIMITS (% BY VOL):	Not Available
AUTOIGNITION TEMP:	Not Available
DECOMPOSITION TEMP:	Not Available
FIRE FIGHTING:	Use water, carbon dioxide or dry chemical to extinguish fires. Wear self-contained, positive pressure breathing apparatus and full firefighting protective clothing. See Exposure Control Methods for special protective clothing. Sulfur dioxide or hydrogen sulfide may be formed under fire conditions. Do not flush to sewer which may contain acid. This could result in generation of toxic and explosive hydrogen sulfide gas.

**REACTIVITY DATA**

STABILITY:	Stable
CONDITIONS TO AVOID:	None known
POLYMERIZATION:	Will Not Occur
CONDITIONS TO AVOID:	None known
INCOMPATIBLE MATERIALS:	This product contains a neutralized dithioacid. Avoid contact with strong oxidizing agents and mineral acids.
HAZARDOUS DECOMPOSITION PRODUCTS:	Thermal decomposition or combustion may produce carbon monoxide, carbon dioxide, hydrogen sulfide and/or oxides of sulfur and phosphorus.

**PHYSICAL  
 PROPERTIES**

APPEARANCE AND ODOR:	Colorless liquid; perceptible odor
BOILING POINT:	Not Available
MELTING POINT:	~12 F; ~-11.1 C (freezing point)
VAPOR PRESSURE:	Similar to water
SPECIFIC GRAVITY:	1.07 @ 25 C
VAPOR DENSITY:	Similar to water
% VOLATILE (BY VOL):	~65 (water by weight)
OCTANOL/H <sub>2</sub> O PARTITION COEF.:	Not Available
pH:	11.0 minimum
SATURATION IN AIR (BY VOL):	Similar to water
EVAPORATION RATE:	Similar to water
SOLUBILITY IN WATER:	Complete

---

**SPILL OR LEAK  
PROCEDURES**

**STEPS TO BE TAKEN IN  
CASE MATERIAL IS  
RELEASED OR SPILLED:**

In addition to the protective clothing/equipment in Exposure Control Methods, wear impervious boots and a rain suit. Cover spills with some inert absorbent material; sweep up and place in a waste disposal container. Flush area with water.

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**WASTE DISPOSAL**

Disposal must be made in accordance with applicable governmental regulations.

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**SPECIAL  
PRECAUTIONS**

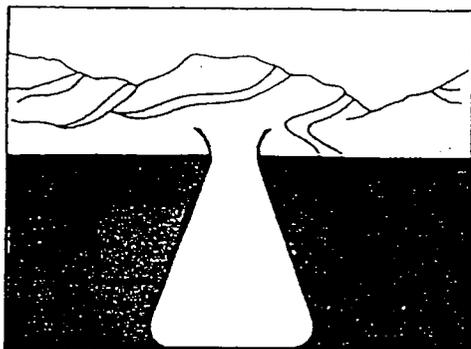
**HANDLING AND  
STORAGE/OTHER:**

AERO 3501 Promoter should not be mixed with acids since evolution of toxic and explosive hydrogen sulfide gas could result. This precaution does not, of course, apply to addition of this reagent to flotation pulps in amounts customarily used in flotation.

---

*Marvin A. Friedman*

Marvin A. Friedman, Ph.D., Director of Toxicology and Product Safety



# Aqueous AERO<sup>®</sup> 3501 promoter

MC 16

AERO 3501 Promoter is a viscous aqueous solution of a dithiophosphate based formulation and is the most powerful of the dithiophosphate collectors for sulfides and middlings of sulfides and gangue.

## ADVANTAGES

**Aqueous solution** — improved handling, mixing and feeding characteristics. Unlike the dry AEROFLOAT Promoters, it contains no sodium carbonate, thereby preventing problems with sludge formation, when dilution water contains calcium and magnesium ions. Fast acting, usually requiring little or no conditioning.

## APPLICATION

Aqueous AERO 3501 Promoter as sold is preferably diluted 5 to 20 times, but can be diluted to any convenient strength. This product has frothing properties. Preferred addition points are after the grind to conditioners and staged to rougher flotation.

## PRINCIPAL USES

Flotation of copper, silver, activated zinc and nickel sulfides and particularly middlings of these sulfides with gangue. Selective against pyrite in alkaline circuit. This product can be used in conjunction with xanthates and Cyanamid's 400 Series Promoters.

## TREATMENT LEVEL

Dosage rates of this powerful collector are usually in the range 0.005–0.05 lb. Promoter/ton (2.5–25 grams/metric ton). Stage addition is usually desirable.

## TYPICAL PROPERTIES

Appearance	Colorless to yellow liquid
pH	13.0
Specific gravity at 30°C.	1.081
Viscosity at 30°C., Brookfield (centipoise)	9.5
Boiling point (°C.)	103
Freezing point (°C.)	
Crystallization begins	+4
Pourable slurry forms	-4
Product solidifies	-9
Freeze-thaw stability	Good

Note: This reagent will become very viscous near the freezing point, but will revert to its original condition at ambient temperatures.

## ENVIRONMENTAL PROPERTIES

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BOD<sub>5</sub> (g. BOD/g. promoter) 0.03 (estimated)

COD<sub>5</sub> (g. COD/g. promoter) 0.8 to 1.0 (estimated)

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### HANDLING

The aqueous AERO Promoters are corrosive to a greater or lesser extent to most metals. It is recommended that storage of either the **strong** or **diluted** solution of the product be in 316 stainless steel or in mild steel tanks equipped with a phenolic liner. Plastic or phenolic type pipe is suitable for transfer of the product in either the strong or diluted form.

### TECHNICAL SERVICE

Technical service and information for making the best use of this product are available through your Cyanamid representative.

### TOXICITY

Prolonged contact of the strong solution with the skin should be avoided. Where contact has been made, water in copious quantities should be used to cleanse. Alkali burns of the skin may result if protective gloves and goggles or face shields are not used during handling. In case of eye contact, wash eye in eye bath immediately for 15 minutes. If taken internally, vomiting should be induced, although the material is considered to be only mildly toxic.

### SHIPPING

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50/55 gallon non-returnable steel drums. Net — 450 lbs., Gross — 498 lbs., F.O.B. Warners, N.J.

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### IMPORTANT NOTICE

The information and statements herein are believed to be reliable but are not to be construed as a warranty or representation for which we assume legal responsibility. Users should undertake sufficient verification and testing to determine the suitability for their own particular purpose of any information or products referred to herein. NO WARRANTY OF FITNESS FOR A PARTICULAR PURPOSE IS MADE.

Nothing herein is to be taken as permission, inducement or recommendation to practice any patented invention without a license.

PENOBSCOT UNIT  
CALLAHAN MINING CORPORATION

HARBORSIDE, MAINE 04642  
TELEPHONE (207) 520-4339

May 13, 1971

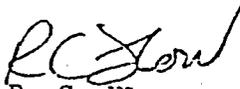
Mr. Stephen W. Groves  
Assistant Engineer  
Environmental Improvement Commission  
Augusta, Maine 04330

Dear Mr. Groves:

Enclosed is a copy of our mill flowsheet showing where  
chemicals are added.

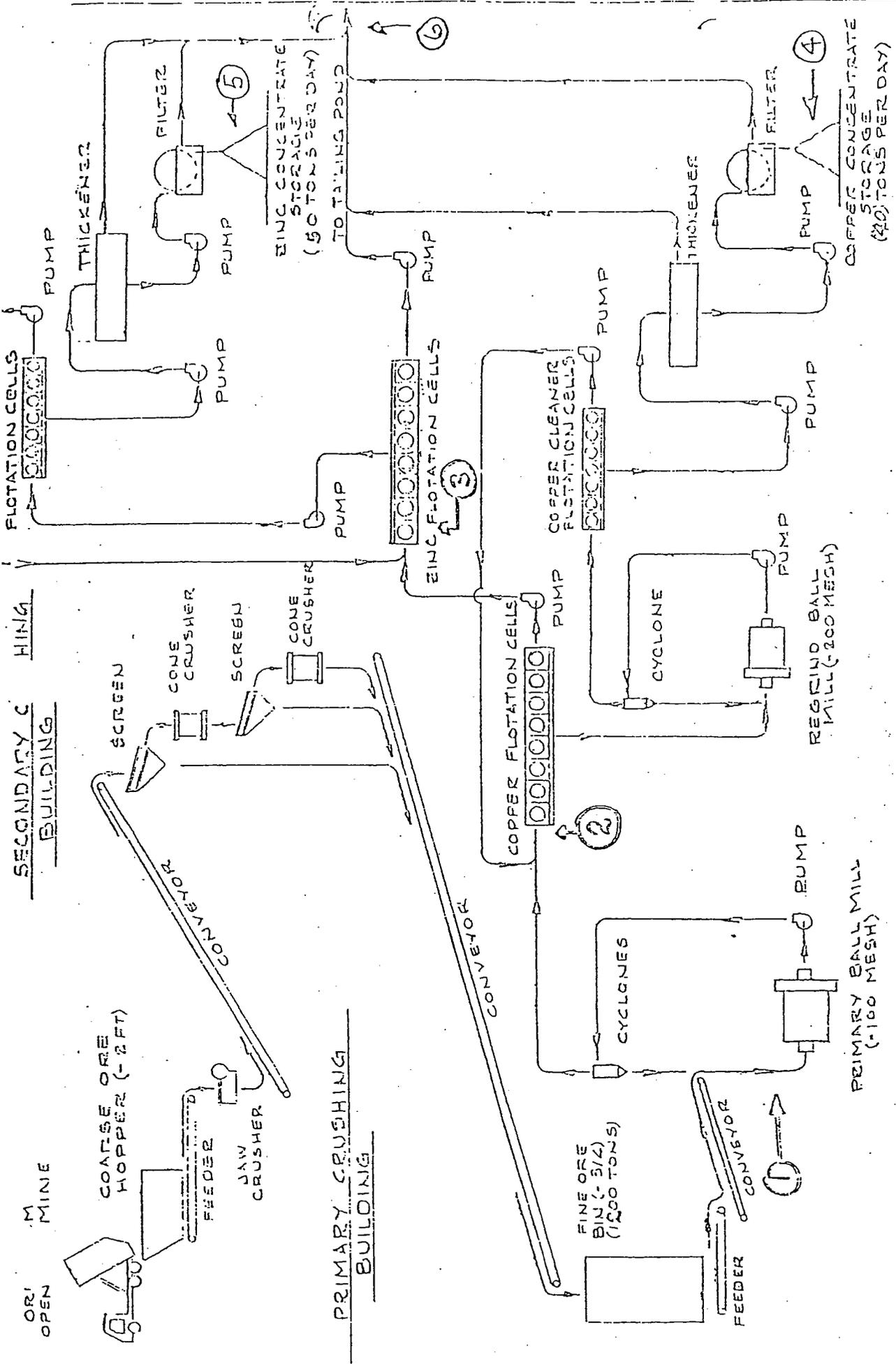
I believe this is what you want.

Very truly yours,

  
R. C. Flow  
Assistant Manager

RCF/jpw

cc: G. Beattie  
C. Kidwell  
C. D. Snead, Jr.



SEE ATTACHED SHEET

7

SEE ATTACHED SHEET

7

CONCENTRATOR BUILDING

CALIFORNIA MINING CORPORATION

CONCENTRATOR BUILDING

CONCENTRATOR BUILDING

1951

1. Ore 625 Tons (Dry)  
5.3% Zn (4% H<sub>2</sub>O)  
Water 400 gpm  
ZnSO<sub>4</sub> .7#/ton of ore
  2. H<sub>2</sub>SO<sub>3</sub> 2% Soln PH 6.5  
(Sulfur 1.7#/ton)  
3501 Collector (Amer. Cyn)  
(0.04#/ton)  
242 Promoter Amer. Cyn.  
(0.01#/ton)
  3. Lime 1.5#/ton  
CuSO<sub>4</sub> Activator  
(.8#/ton)  
Sodium Aerofloat (Amer. Cyn)  
(.15#/ton)  
Amyl Alcohol Frothers  
(.01#/ton (as needed)(Amer. Cyn)  
(F-71)
  4. 40T concentrate  
(5% Zn)  
(25% Cu)  
(9% Moisture)
  5. 50T Zinc Conc.  
52.0% Zn  
0.8% Cu  
9.0% Moisture
  6. 535 Tons Tailings  
24% solids  
.6% Zn  
.2% Cu
- Decant H<sub>2</sub>O to Mill  
P.F.M.  
Cu 0.1  
Zn 0.6  
Pb 0.0  
Fe 0.1



DEPARTMENT OF THE ARMY  
NEW ENGLAND DIVISION, CORPS OF ENGINEERS  
424 TRAPELO ROAD  
WALTHAM, MASSACHUSETTS 02154

REPLY TO  
ATTENTION OF:

NEDOD-P

27 June 1972

Goose Pond Reclamation Society  
c/o Mr. Frederick M. Beck  
Director of Exploration  
Callahan Mining Corporation  
41 Union Wharf  
Portland, Maine 04111

Dear Mr. Beck:

On June 6, 1972, the Goose Pond Reclamation Society conducted a general meeting which was attended by Major Cook and me along with representatives of several other Federal and State agencies. We appreciated the opportunity to see this forum in action and to hear the concerns of all of the interests represented. During our visit we had the occasion to inspect tailings pond and its retaining embankment. Certain aspects of this structure caused us to express concern to the Society over the stability of the tailings pond and its supporting embankment. After on-site review of this matter, it was felt that more qualified evaluation was required before the matter could be discussed in any further detail.

Upon return to our office, we reviewed this matter further and determined that, while this office has considerable experience in dam construction, tailings ponds were an area requiring special expertise. At the request of this office, the Department of Interior agreed to make a representative of the U.S. Bureau of Mines available to assist in our evaluation. On June 21 and 22, a representative from the Bureau of Mines and two representatives from this office's Foundations and Materials Branch accompanied Major Cook and myself to Harborside, Maine to accomplish an evaluation of the tailings pond and retaining structure. At the conclusion of our visit, Mr. Beck representing Callahan Mining Corporation was provided a list of concerns as developed by this group and had the opportunity to discuss them in detail prior to the group's departure.

NEDOD-P  
Goose Pond Reclamation Society

27 June 1972

In conclusion, it was the consensus of this group that concern over the stability of the tailings pond and supporting embankments warranted further investigation and exploration to determine conditions within the tailings pond itself. Technical recommendations without knowledge of existing conditions within the tailings would be unsubstantiated. It was however recommended that the firm explore the resources of appropriate governmental and private agencies to conduct further evaluation of this matter.

This agency will continue to consider the Goose Pond Reclamation Society as the appropriate forum for responsive resolution of this and other matters associated with the reclamation effort. We appreciate the opportunity to pursue those matters of interest to our office in open forum and look forward to further discussions.

Sincerely yours,



F. W. MOEHLE  
Chief, Permits Branch  
Operations Division

28 1972

Appendix G



# United States Department of the Interior

BUREAU OF MINES  
LIAISON OFFICE MAINE  
FEDERAL BUILDING POST OFFICE  
AUGUSTA, MAINE 04330

*Boyle 2/1/72*

HSJ	<i>[initials]</i>
WPL	<i>[initials]</i>
WAN	<i>[initials]</i>
JTM	<i>[initials]</i>
GF	<i>[initials]</i>
AM	<i>[initials]</i>

SEP 22 1972

September 21, 1972

Mr. V. L. Andrelinas  
Chief, Operations Division  
Department of the Army  
New England Division  
Corps of Engineers  
424 Trapelo Road  
Waltham, Massachusetts 02154

Dear Mr. Andrelinas,

Reference is made to your letter of September 15 requesting a statement of the Bureau of Mines' conclusions on the stability of the mill tailing impoundment of Callahan Mining Corporation at Goose Pond, Hancock County, Maine.

The mine site and mill tailing impoundment were inspected August 11, 1972, by Dr. James J. Scott, former Assistant Director, Mining, and currently acting as Special Assistant to the Director. Milling operations at the plant were terminated in mid July. Pertinent conclusions from Dr. Scott's report are quoted below:

1. Callahan Mining is doing everything possible to prevent environmental damage to the scenic Cape Rosier area and their efforts should serve as a model to other mining companies who are closing down mines.
2. There is little or no instability problem relative to their ten acre tailing disposal area. The heavy, coarse rock face virtually assures its long-term stability. Planned surface drainage and vegetation will further strengthen the structure.
3. Leaching of heavy metal ions out of the tailings during periods of heavy rainfall could be a problem. I am confident that this problem can be eliminated by establishment of vegetation and surface drainage to prevent water from seeping through the tailings."

Please advise me if I can be of further assistance.

Very truly,

cc: Director's Reading File  
Richard H. Mote  
James J. Scott  
Frederick Beck, Callahan

SIGNED  
Robert W. Holliday  
USBR Liaison Officer - Maine

RICHARD A. SWEET  
BOX 91  
CUMBERLAND CENTER, MAINE 04021  
TELEPHONE (207) 829-5768

*7/1/68 Copy to the [unclear]*

Goose Cove Sediment Study  
Harborside, Maine

The following report is the result of an investigation of Goose Cove on Cape Rosier, Harborside, Maine, as requested by Callahan Mining Corporation. The purpose of this investigation was to determine the present heavy metal content of the sediment in the cove as background for deciding whether or not to dredge the cove prior to dam removal.

Samples were collected by gravity sampler and by a manually operated sampler from row boat. Both samplers caught the sediment in PVC pipe driven into the sediment by a weight in the case of the gravity sampler or by hand in the case of the manually operated sampler. In places where the sampler penetrated one foot or less of sediment to refusal, the sample either would not stay in the sampler or it stayed in the sampler but was jumbled in which case it was collected in a plastic bag.

When using the manually operated sampler the thickness of the sediment was measured from approximately the top of the sediment to refusal. In all but one case the thickness of the sediment collected was less than the measured thickness. In all cases it is felt that the sediment not picked up in the sampler was older than the open pit mining operation. The original or pre-open pit sediment was usually charcoal gray with abundant shell fragments and the visible gritty nature of the original sediment may have resulted in less adhesion to the sides of the sampling tube.

Samples collected in PVC pipe were split in half lengthwise, logged, and approximately one half was sent to be assayed while the other was saved

future inspection. Logging of the samples was mainly by color, sediment size, plant and animal remains, and in the case of sand content, mineralogy. Samples for assaying were separated mostly on the basis of color differences and to a lesser extent on the presence of plant or animal remains.

#### Sediment Description:

In general the most recent sediment is a light gray fine sediment with little or no visible plant remains and thought to be partly the result of talcose effluent from open pit mining operations. In the central area of the cove especially in the deepest trench a  $\frac{1}{4}$  to  $\frac{1}{2}$  inch dark gray layer of sediment has been deposited on top of the light gray talcose sediment (see samples 1, 2, 3, 7, 12, and 13). It is suspected that this has been deposited since the termination of mining operations.

In most cases, below the recent light gray talcose sediment is a dark gray fine sediment containing shell fragments and plant remains. The contact with the sediment above is gradational and occasionally there may be varves or layers ( $\frac{1}{2}$  inch) of light gray and dark gray sediment suggesting nonuniform deposition from mining operations. In sample one the top portion of the dark gray sediment contained fragments of talc, chlorite, and quartz minerals and no visible sulfides. It is felt that these were deposited at the start of open pit mining operations.

Samples one and two show an intermediate zone between the light and dark gray sediments of brown fine sediment with shell and plant remains in one and none in the other.

#### Assay Values:

Samples were sent to Technical Service Laboratories, Toronto, Ontario, Canada, and analyzed for copper, lead, zinc, and cadmium. Extractions were with hot 50% aqua-regia. The certificate of analysis along with a brief

Description of each sample is appended to this report. Samples with the same number were taken from the same sample tube. The letter "a" represents the lowest (vertically) sample in the tube and the letter "c" the highest. Sample 15 was taken from the next cove to the North (shown on the photo) for background purposes.

In general, the uppermost sample at each location (top layer of sediment) is anomalous as was expected. The average thickness of anomalous sediment in the cove is approximately eight inches. All samples showed values above background except in the case of cadmium which either matched or was close to background in most pre-open pit sediment samples.

There is a marked contrast between above background values. Samples designated as original sediment or pre-open pit are 1a, 1b, 2a, 2b, 3a, 6a, 7a, 8a, 9, and 13a. In most of these samples, it is suggested that they show higher than background values for the following reasons:

- 1) The pre-open pit sediment must have been contaminated by the natural outcrop of heavy metals in the cove which was mined by the open pit.
- 2) The natural absorbency of clay minerals for some inorganic compounds should have taken in some of the anomalous heavy metals deposited on top at the time of the open pit.
- 3) In general the less thickness of pre-open pit sample collected the higher the heavy metal values. This is expected because of the contamination at the top because of the overlying open pit sediment.
- 4) The gradational contact between units in some cases possibly would have meant some contamination of samples when they were separated for assaying.

Those samples thought to be relatively uncontaminated (1a, 1b, 2a, 2b, 3a, 3a, and 9) and representing pre-open pit sediment showed an average value of: 142 ppm copper, 99 ppm lead, 510 ppm zinc, and 7 ppm cadmium.

For comparison purposes, the following is taken from The Encyclopedia of Geochemistry and Environmental Sciences, Volume 4 A, 1972. ".....the reported content (of copper) of the deep-sea clays (250ppm) is almost five times as great as the mean continental figure." "Its (lead) average abundance in the crust is about 15 ppm by weight." "The behavior of lead during weathering and sedimentation is strongly dependent on environmental conditions, a fact which is reflected by the highly variable lead content of soils (2-200 ppm)." "The mean continental crustal abundance (of zinc) has been estimated at 70 ppm zinc." ".....the composition of deep-sea clays, which show zinc concentrations well r twice those of the estimated mean crustal abundance or mean shale composition." The average cadmium concentration in soils is 0.5 ppm cadmium. "An exceptional concentration (of cadmium), also with zinc, has been noted in oceanic phosphate rock (leached guano), ie., 100 ppm (Rankama and Sahama, 1950)."

Thus, this pre-open pit sediment even though slightly higher in heavy metals than the one background sample is mostly low enough to fit naturally occurring heavy metal concentrations in the environment.

The sediment overlying this pre-open pit sediment is anomalous and the heavy metal values shown are felt to be mostly the result of the effluent from open pit mining operations. It is not known what percentage of these heavy metal values might be toxic to marine animals but the relative lack of shell fragments in this sediment suggests that marine animals will naturally avoid contact with it. Living sea urchins were caught during sampling and it is thought to be evidence of a toleration of the present environment of the cove by living sea animals. The shells were not analyzed for heavy metal content.

Low organic rich sediment ( $\frac{1}{4}$  to  $\frac{1}{2}$  inch) appears to be accumulating on top of the anomalous sediment in some areas of the cove and in some cases in a fairly direct line with the present flow of tidal water through the dam. It may be that the flow of tidal water over the sediment prevents a buildup of toxic water above the anomalous sediment and thus encourages the growth of marine organisms.

The dashed lines on the attached Goose Cove map are contour intervals showing the thickness of anomalous sediment. Most of this material was apparently introduced to the cove through the 16 inch discharge pipe shown on the map. As the contours show, the greatest accumulation is near the mouth of the pipe with lesser accumulations in the trench on the West side of the cove center and near the shore in the Southeast corner. It is also spread over the rest of the cove in lesser accumulations (within the 4 inch anomalous sediment contour). Approaching the North end of the cove as it opens on Penobscot Bay thinning of all sediment occurs.

Total quantity of anomalous sediment is approximately 2506 cubic yards. This quantity lies within the four inch anomalous sediment contour. No calculation was made outside this contour because it is felt that usually approximately four inches of anomalous sediment butts against the steeply sloping rocky sides of the cove. Other anomalous sediment contours contain:

6 inch — 1760 cu. yds.  
8 inch — 760 cu. yds.  
10 inch — 259 cu. yds.

Average values for all anomalous sediment assays are: 3200 ppm copper, 900 ppm lead, 9000 ppm zinc, and 30 ppm cadmium. Accuracy of numbers in these high ranges is probably  $\pm 30$  per cent.

Dam Removal:

Possible effects on the environment of Goose Cove have been considered as

a result of removing the tidal dam at the Southeast end of the cove. If the dam is removed the expected result is increased turbulence in the water from the dam out to approximately the first bend in the discharge pipe (110 feet) about 20 feet beyond the mean low water mark (5 foot contour). An unknown but probably small amount of anomalous sediment would be expected to enter the tidal flow and be redeposited farther out. The increased quantity of water flow in and out of the cove would not be expected to affect the anomalous sediment except that it may encourage an increasing amount of marine life to take hold on the anomalous sediment, burying the anomalous sediment below new organic rich layers as mentioned earlier in the report. Therefore, except for the small turbulent area in the Southeast corner of the cove near the dam, affected by gravity water flow as it comes through the channel at the dam, anomalous sediment should not be adversely affected in the cove.

If removal of the anomalous sediment in the cove is attempted before dam removal, a number of adverse conditions would be expected. If a dredge is used to remove the anomalous sediment much of the anomalous sediment would go into suspension as removal operations were carried out. Tidal flow would not only carry this suspended sediment over the cove but would probably redeposit it in Penobscot Bay. It would be extremely difficult to remove only the anomalous sediment and as a result mixing with the original sediment would occur. If the entire cove were to be dredged, then the new and probably less toxic sediment presently being deposited would be taken off. Therefore, it is felt that dredging would only disturb what appears to be a satisfactory balancing of the environment in the cove.

In summary, it is not felt that removal of the dam would seriously affect the present environment of the cove provided the sediment is not mechanically removed by dredging as well.

## DEPARTMENT OF TRANSPORTATION

STATE OFFICE BUILDING

AUGUSTA, MAINE

04333



ROGER L. MALLAR  
Commissioner

August 23, 1978

Mr. William A. Nicely  
Callahan Mining Corporation  
CBT Plaza  
Darien, Conn. 06820

Dear Mr. Nicely:

Recently, Mr. Fred Beck, Consulting Engineer of Yarmouth, Maine, requested that this Department advise you of any obligations your corporation has to this Department regarding the Goose Falls Dam in Brooksville, Maine. I have reviewed the history of this structure and determined that on June 29, 1966, a letter was written to your concern with a series of stipulations. This is the correspondence with which Mr. Beck had concern. A further research of our records reveals that the key stipulations involving this Department and your company concerning the dam were eliminated. The following excerpt from the Commission Record of August 31, 1966, is, I believe, self-explanatory:

"Chief Engr. advised Commission that stipulations #7 and #8 included in Item #23 of the Commission Record of 6-29-66 are contained in the lease from the Maine Mining Bureau to Callahan Mining Corp. The Commission therefore voted to rescind these stipulations."

Our major interest in this entire matter is for the integrity of the bridge and we have little interest in whether or not the dam is retained. It is our understanding that the opening in the dam was enlarged a short time ago by the company which is managing the area for raising salmon. We are currently making a field review to insure that the work would not harm the bridge structure.

It would appear that this disposes of the matter concerning your obligation to this Department for at least the time being. Of course, if for some reason your concern was to be involved in the further removal of the dam our interest would again be to insure the integrity of the bridge. If you have any question or comment about any of the above, please feel free to write directly to me.

Sincerely yours,

BUREAU OF HIGHWAYS

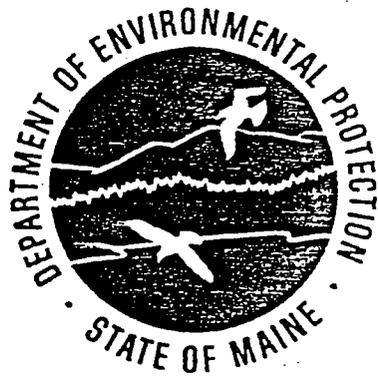
Martin C. Rissel  
Engineer of Maintenance and Operations

MCR/jd  
cc: F. Beck  
A. Sirois

REGULATIONS FOR REGISTRATION, INSTALLATION, OPERATION AND  
ABANDONMENT OF UNDERGROUND OIL STORAGE FACILITIES

CHAPTER 691

Department of Environmental Protection



C. ABANDONMENT BY FILLING IN PLACE

1. Abandoned facilities and tanks shall be removed, except where the owner can demonstrate to the Department that removal is not physically possible or practicable because the tank or other component of the facility to be removed is either:
  - a. Located beneath a building or other permanent structure which cannot be practically replaced;
  - b. Of a size and type of construction that it cannot be removed;
  - c. Inaccessible to heavy equipment necessary for removal; or
  - d. Positioned in such a manner that removal would endanger the structural integrity of nearby tanks.
  
2. A facility or tank owner may apply to the Board for a variance to abandon a facility or tank in place rather than abandon the tank or facility by removal. The Board may grant such a variance request if it finds that:
  - a. Abandonment by removal is not possible or practicable due to circumstances other than those listed in paragraph 1 above;
  - b. The procedures outlined in Appendix K for abandonment in place will be followed in sequence; and
  - c. The granting of a variance shall not pose a threat to a private or public drinking water supply or the quality of ground water, and is consistent with the intent of this rule.

D. NOTIFICATION REQUIREMENTS

1. The owner or operator of a facility or tank which is to be abandoned shall notify the Department and the local fire department having jurisdiction. This notice shall be filed in writing at least ten (10) days prior to abandonment, except that when ownership of the facility or tank is unknown, the current property owner shall be responsible for compliance with the requirements of this section. This notice shall include:
  - a. The name, mailing address, and telephone number of the owner;
  - b. The mailing address and location of the facility;
  - c. The size(s) of tank(s) to be abandoned or taken out-of-service;
  - d. The type(s) of products(s) most recently stored in each tank;
  - e. The registration number of the facility and tank(s) if registered under this rule;
  - f. If abandonment in place is planned, the criterion(ia) used for justifying abandonment in place, as listed in Section 8(C)(1), above;
  - g. The approximate age of the tank, if known; and
  - h. The date upon which the facility or tank is to be removed or when a variance has been granted pursuant to section 8(C) of this rule, the date on which the tank or facility will be properly abandoned on site.

3. The tank owner shall keep a permanent record of the tank location, the date of abandonment, and the method of conditioning the tank for abandonment.
  
4. The tank owner shall be responsible for attaching to the deed of the property on which the tank is located a notice that an underground oil storage tank which has been abandoned in place pursuant to Section 8(C). exists on the property. The deed notation shall be executed within 30 days of completion of the abandonment.

9. SEVERABILITY

Should any provision of this rule be declared invalid or ineffective by a court decision, the decision shall not invalidate any other provision of this rule.



## Reference 7

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## Marine Challenges Encountered by a Small Mine on the Maine Coast

By

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Offshore Technology Conference on behalf of American Institute of Mining, Metallurgical, and Petroleum Engineers, Inc., The American Association of Petroleum Geologists, American Institute of Chemical Engineers, American Society of Civil Engineers, The American Society of Mechanical Engineers, The Institute of Electrical and Electronics Engineers, Inc., Marine Technology Society, Society of Exploration Geophysicists, and Society of Naval Architects & Marine Engineers.

This paper was prepared for presentation at the Second Annual Offshore Technology Conference to be held in Houston, Tex., April 22-24, 1970. Permission to copy is restricted to an abstract of not more than 300 words. Illustrations may not be copied. Such use of an abstract should contain conspicuous acknowledgment of where and by whom the paper is presented.

### ABSTRACT

Callahan Mining Corporation is currently mining copper and zinc ore from an open pit mine on the edge of Penobscot Bay in Maine. The open pit occupies an area once largely covered by a salt water pond. The mining operation utilizes conventional mining and milling techniques and in this respect perhaps could not be considered a true marine mining operation. However, many obstacles had to be overcome due to the proximity of the ocean before the mine could be brought into production. Problems with which inland mines do not have to contend are faced daily. These include effluent control, marine mud stability, salt water encroachment, reclamation, and exploration.

The ore deposit is a stratiform massive sulfide body in early Paleozoic volcanics. The principal ore minerals are sphalerite and chalcopryrite with minor galena. Associated minerals include chlorite, talc, and carbonate.

Illustrations at end of paper.

The deposit was discovered in 1880 at low tide by a clam digger. Surface ore outcrops were entirely below high tide. The mine was developed and mined from three shafts. Apparently the deposit became unprofitable in about 1887. A re-evaluation in 1964 by the Callahan staff prompted the present open pit operation. Production is currently at the rate of 700 tons per day.

Exploration for additional ore deposits is complicated by the presence of salt-saturated mud in estuaries and salt water covering geologically favorable prospecting ground. Many conventional inland exploration techniques are useless near these areas.

The ocean presence has added substantially to the mining costs, thus narrowing the profit margin. New techniques must be developed by the mining industry to cope with oceanographic problems. Some of these challenges are being met at Cape Rosier and can be applied to future mining ventures faced with similar marine problems.

## INTRODUCTION

The Penobscot Mine on the Maine coast is not a "marine mining" operation in the strictest sense. For the most part, conventional techniques of mining and milling are in use and the ocean is a nuisance. However, by being located at the sea-land interface, there are a number of factors which influence the operation which would not be encountered inland. The engineering challenges of dealing with the shallow estuary were relatively easily mastered. The challenge to mineral exploration still exists and is a subject of continuing effort. The nation's sea-land interface is probably one of the most popular and valuable multiple use areas in the country. In Maine it has scenic beauty, is sought after for summer homes, provides food and shelter during parts of the life cycles of innumerable marine species, and is the basis for commercially important coastal fisheries. It is an area high on most lists for environmental protection. It is natural that the addition of another "user" to this area would be resisted, particularly when that user represents an industry which has a past record of environmental abuse. The greatest challenge to Callahan Mining Corporation has been to operate a mine in a way which does not pollute or otherwise adversely change the environment and yet returns a profit to the stockholders. This paper will describe some of the problems encountered and ways in which they were or are being solved.

## HISTORY

Eastern coastal Maine (Figure 1) has had a long sporadic history of mineral exploration and minor metal production. During the 1880's there was a mining boom, complete with a stock exchange located in Blue Hill. Prospecting was intense during this period and the deeply incised coast provided a relatively high percentage of bedrock exposure in an area otherwise mostly covered with glacial till.

Production during this period was largely from the Douglas and Twin Lead Mines at Blue Hill (Figure 1). A smelter at Blue Hill reduced the copper ore and the product was shipped to the populated areas further south by coastal schooners.

About ten miles west of the Blue Hill

mining camp an outcrop of massive zinc and copper ore was discovered at low tide by a clam digger. This outcrop occurred in a tidal estuary known as Goose Falls Pond (Figure 2). Subsequently a shaft was sunk on the nearby shore and production of high grade zinc-copper ore commenced. The ore was taken from Goose Cove to Castine (Figure 2) by barge and piled on a dock. Periodically, coastal schooners would load the ore and deliver it to smelters in the south.

The ore at the Penobscot Mine was eventually mined from three shafts and production from 1881 to 1883 was about 10,000 tons. Apparently, low metal prices in 1887 forced the mine to close. It remained closed until 1914, at which time an attempt to reopen the mine proved unsuccessful.

In 1940 the St. Joseph Lead Company conducted a drilling program on the property. This was supplemented in 1942 by drilling conducted by the U.S. Bureau of Mines. Although numerous intersections of copper and zinc sulfides were encountered, apparently the property was considered uneconomic. Additional diamond drilling was done by the Bureau of Mines in 1950. The property was eventually optioned by the Penobscot Mining Company, Ltd., of Toronto in 1956.

This company drilled a few holes from the surface, cleaned out the old workings, and drilled from underground. The property was brought to the attention of Callahan Mining Corporation in 1964. Re-evaluation of all past work indicated that sufficient values might exist to warrant an open pit mining operation. A lease was negotiated with the Penobscot Mining Company and the property is currently being mined under the terms of this lease.

## GEOLOGIC SETTING

The base metal mineral occurrences in eastern coastal Maine occur in early Paleozoic volcanic and sedimentary rocks. The volcanic rocks range in composition from mafic pillow lavas to felsic fragmentals. Rhyolite domes and rhyolites of probable tuffaceous origin are common. The sedimentary rocks are present as schist, gneiss, and quartzite, and may represent, in part at least, sedimentary accumulations derived

from and deposited during volcanism. The sediments and volcanics are intruded by igneous rocks, mostly of granitic composition.

The base metal deposits in eastern coastal Maine occur in volcanic rocks and associated sediments. Metamorphism due to subsequent igneous activity has in places affected both the metal deposits and the enclosing rocks.

### PRESENT OPERATION

At present, the mine consists of an open pit, roughly circular in shape, which will have an ultimate depth of 340 feet below sea level (Figure 3). The present depth is 150 feet below sea level. The pit covers about 9.4 acres and when "mined out" will have produced over seven million tons of ore and waste. Mining and milling began early in 1968.

The ore occurs as lenticular pods of massive zinc and copper sulfide ore. It is a stratiform deposit in a sequence of fragmental volcanic rocks. Associated chlorite, talc, and carbonate rock is either barren or, particularly in the deeper levels, contains disseminated sulfides. The ore is trucked to a nearby mill. Approximately 700 tons of ore with an approximate grade of 6% zinc and 1% copper are processed daily. The mill is a conventional flotation mill with one exception; it was designed to operate with salt water rather than fresh water.

Consideration was given to the feasibility of loading the metallic concentrate onto barges, or other vessels, for cheap transport to a smelter. However, due to the relatively small size of the mine, trucking to the railroad 30 miles away in Bucksport and shipment to smelters in Quebec and Pennsylvania by rail proved to be the more economic.

### LEGAL CONSIDERATIONS

In order to mine the deposit with an open pit, it was necessary to drain a salt water estuary. This estuary, named Goose Falls Pond, covered 90 acres. The name is derived from the falls created during ebb tide (Figure 3).

The normal tides for this portion of the Maine coast range from a 0.0 foot low to a

+8.5 foot high, with extremes ranging from -1.9 foot low to +11.5 foot high. The restricted rocky entrance allowed water to flow into the pond only during the high portion of the tidal cycle. This resulted in an average water level fluctuation within the pond of approximately three feet.

Briefly, the plan was to build one dam at the mouth of the estuary to prevent the tide from entering the pond and to build another dam at the head of the estuary to divert the fresh water drainage from 1600 acres of adjacent forest land to another drainage area. The pond could then be pumped dry and inflow would be minimal (Figure 3).

Goose Falls Pond was bordered on the east by a privately owned wildlife sanctuary and on the west by land owned or leased by Callahan Mining Corporation. The pond waters, land below low tide, and the mineral rights below low tide are owned by the State of Maine. The intertidal land is owned by the adjacent landowners. In order to drain the pond, the riparian rights of the adjacent landowners would have to be temporarily taken and held by the State. The owners of the wildlife sanctuary objected to this seizure. The Maine Mining Bureau, administrator of the State's mining rights, questioned whether it had the authority to authorize draining of the pond under these circumstances; an act of the legislature was considered necessary.

Accordingly, a bill was introduced to a special session of the legislature in 1966 which would allow the State, through the Mining Bureau, to authorize drainage of the pond and temporary taking and holding of the adjacent landowners' riparian rights. It should be noted that before the Governor would support the bill and submit it to the legislature, four State agencies had to submit their recommendations to him. These were the Departments of Sea and Shore Fisheries, Forestry, Inland Fish & Game, and Water Improvement Commission. An ecologist was retained by the Company to make independent studies and to assist in operational planning. Understandably, there was considerable lobbying in opposition but the local residents generally supported the planned operation. The legislature referred the bill to the State Supreme Court for a decision on its constitutionality. The Supreme Court ruled in

favor of the bill and it was subsequently passed by the legislature and signed into law.

The Mining Bureau issued a mining lease to the Company shortly after the legislative action was taken. Concurrently, permission was sought from the U.S. Corps of Engineers to construct a dam at the tidal mouth of Goose Falls Pond, which was considered a navigable waterway. The U.S. Fish and Wildlife Service was consulted by the Corps of Engineers and conducted studies with the assistance of the State agencies mentioned earlier. The Fish and Wildlife Service eventually recommended that if a dam was built, the pond should be kept full of fresh water and a coffer dam be built around the perimeter of the pit. This plan was considered unsafe and impractical by the Company. The Corps of Engineers finally approved building the dam according to the plan recommended by the Company. The last authorization required for the project was a permit from the State Water Improvement Commission to pump the pond and discharge the water into Penobscot Bay. This permit also provided for effluent quality standards and monitoring of effluents discharged during mining and milling. The monitoring is currently supervised by the State Department of Sea & Shore Fisheries. This agency has worked closely with the Company, with other interested agencies, and with concerned conservation groups to assure that the living resources of this portion of Penobscot Bay are not adversely affected.

#### CONTINUING PROBLEMS

Current mining problems which can be related to proximity to the ocean can be grouped into four categories; pollution, salt water encroachment, marine sediments, and rehabilitation. These problems are especially "visible", principally because the ocean-land interface is a high multiple-use area where conflicts of use are bound to be at a maximum.

##### Pollution

Four types of pollution pose problems for the mining operation. These are noise, silting, heavy metal, and scenic.

The noise pollution is a factor due to the proximity of numerous residences. Heavy trucking, drilling, and blasting are the principal contributors. The noise is minimized as

much as possible by (1) only day shift drilling, (2) no graveyard mining shift, (3) carefully controlled pit blasting, (4) no secondary blasting of oversize boulders, and (5) careful maintenance of equipment to minimize muffler noise. Despite these efforts occasional complaints are received.

Silting is taking place in Goose Cove (Figure 3). Early in the operation this was partly due to the effluent from the mining operation. This has been largely cured with the use of several settling ponds. After heavy rain storms the effluent contains silt, just as do all natural fresh water runoffs into the ocean. In addition to the settling ponds, a 16" pipeline has been extended 400 feet from shore to the mouth of Goose Cove to help disperse any silt. The principal cause of silting in Goose Cove, however, is probably natural silting which would be expected in a cove which no longer has a tidal current to keep the cove scoured.

The continuously monitored effluent from the mining and milling operation contains trace amounts of heavy metals. These amounts are higher than found in raw sea water. Periodic testing of clams and other invertebrates in the vicinity has indicated a higher than normal heavy metal content, and this apparently has increased since startup of the mine. Unfortunately, there were insufficient studies conducted prior to mine startup to establish a normal background for the area. Although there are probably a number of factors contributing to the buildup of heavy metals in shellfish, it can only be assumed that the mine is one of the contributors. Other possibilities include continuing erosion of previously operated sulfide occurrences, disturbance of metalliferous bottom sediments due to storms, pollution from the Penobscot River, or pollution from toxic paints used on the 10,000 Ton maritime training ship "State of Maine" which is docked in nearby Castine (Figure 3). There are probably physical and chemical variations of the sea water such as temperature, organic content, etc., which also contribute to the concentration of heavy metals in shellfish. Insufficient sampling has been conducted to date to establish any valid relationships.

Recently, the Company performed tests in which the effluent was recycled and used instead of raw sea water in the mill feed.

Preliminary tests have been encouraging and although no benefits are derived metallurgically, the concept of a closed system is particularly attractive to a company management concerned with pollution as well as to governmental agencies. It is highly probable that systems developed by Callahan on Cape Rosier in cooperation with governmental agencies will become the basis for regulations under which future mining operations on the Maine coast and possibly other coasts will have to operate.

Scenic pollution simply means that it is impossible to operate an open pit mine and not affect the traditional Maine coast scenery. In order to minimize the problem, all buildings are placed inconspicuously behind a hill and barren areas and dumps are being planted with grass and trees. A local artist has helped by painting a corrugated iron pump house on Goose Cove to resemble a lobster shack. The mine is, incidentally, also a tourist attraction and draws crowds during the summer months for regular scheduled tours.

#### Ground Water

The ground water table in the vicinity of the mine is being lowered due to continuous pumping to keep the mine dry. Consequently, some of the neighbors' wells in the cone of influence have gone dry. Although under Maine law the Company is not liable, deeper wells were drilled for those affected. However, as might be expected, salt water encroachment into the ground water has become a problem. This is being relieved by providing those affected with water from Company wells away from the influence of the salt water. Salt water encroachment occurs when the load of fresh water is relieved by pumping or other causes from a coastal area thus causing the underlying salt water-fresh water interface to rise. This interface eventually intersects the drilled water wells. Raising the pump intakes above this interface is a temporary solution but doesn't solve the problem.

#### Clay and Mud

Goose Falls Pond was a shallow pond with up to 90 feet of mud and clay in the bottom. Three test borings were made to determine the nature of the bottom sediments. A typical boring encountered 33 feet of organic silt at the top, followed by 45 feet of gray silty clay, followed by 5 feet of gray gravelly silty sand.

Soil tests indicated that a maximum steepness of slope of 4:1 (14°) would be safe.

On June 29, 1968, the pit had reached a depth of 60 feet below sea level. There was a minor mud slide at the northeast side of the pit but this was not serious and the mud was quickly removed. On July 23, 1968, the mud again began moving at the northeast side of the pit. This time it did not stop as before, however, and within 8 hours it had filled the bottom of the pit to a depth of 25 feet. It is significant that when the mud came to rest the surface was essentially horizontal, indicating that once movement had started, the mud became fluid, much like molasses. It took approximately a month to remove the 225,000 tons of mud from the pit. One power shovel had been completely buried and required extensive repairs. A series of rock dikes with finger dikes were constructed to hold back the mud; so far these have been successful.

A subsequent boring and soil test into the mud indicated that only the organic silt was involved in the slide. There was little effect on the underlying clay. The shear strength of the organic silt was considerably reduced by the slide. The in-place water content of the organic silt did not change appreciably due to the slide (approximately 66% by weight).

The problem of where to put the mud from the pit was soon resolved when it became apparent that it could be used as topsoil on the dump rock and thus provide an ideal base for seeding and planting. The salt apparently leaches fairly quickly from this material.

#### Rehabilitation

Rehabilitation of the mine site is a continuing effort and involves recommendations from the Soil Conservation Service, the State Forestry Department, and local residents. The eventual decision of what to do with Goose Falls Pond when mining is completed will rest with the Town of Brooksville. Three options appear possible; it can be returned to its original state as a saltwater estuary with a tidal falls; it can become a fresh water lake (the deepest on the Maine coast); or a channel can be opened from the ocean and it can become a totally protected deep water harbor. In any case, the affected land portions will be landscaped and planted

as much as possible and could eventually benefit future recreational or residential use of the area.

### EXPLORATION

The targets for mineral exploration in eastern coastal Maine are massive base-metal sulfide deposits containing zinc, copper, lead, and silver. These deposits are typically fairly good electrical conductors, although metamorphism and structural deformation often reduce their conductivity considerably. In addition, the sulfides and their enclosing host rocks are usually relatively soft and consequently occupy the topographic lows in the region. Hence, the deposits are often deeply buried with glacial till or marine clay or both and physical exploration for outcrops is useless. Recognizable alteration "halos" around these deposits do not exist. Therefore, exploration must be of a geochemical or geophysical type localized within areas of favorable volcanic stratigraphy.

Geochemical sampling is used extensively in Maine to locate general areas of highly metalliferous soil. However, pinpointing of drill targets with geochemistry is impossible due to local migration of metal ions and "masking" of targets by impervious clay. The clay along the coast is the product of a once higher sea level. The clay deposits are saline, have a low conductivity, and act as a very effective geochemical and geophysical shield.

So far, no systematic geochemical sampling of the ocean bottom has been attempted even near favorable areas such as the Penobscot Mine on Cape Rosier. The present state of the art is such that until geochemistry becomes more definitive for the land areas, its application to underwater areas near shore is not warranted.

Geophysical prospecting techniques offer the best chance for locating massive sulfide deposits under salt water along the Maine coast. Yet, the problems are formidable. Not only is it probable that the ore deposits are buried under highly conductive marine clays, but conductive sea water is also a hindrance to most geophysical techniques.

It is likely that both the saltwater and marine clays are more conductive than

possible ore bodies. These barriers would tend to negate any techniques which are designed to measure slight conductivity differences within the earth. It is possible that inductive techniques which could differentiate between horizontally and vertically oriented conductors would be useful. The ore deposits generally have a strong vertical component in an area of steeply dipping rock units.

The Penobscot Mine is not associated with any magnetic minerals — or lack of such minerals. Therefore, the use of a magnetometer would not be effective. Naturally, if deposits associated with magnetite or pyrrhotite were being sought the magnetometer would be very useful.

Since there is considerable mass associated with large massive sulfide deposits, gravity measurements may be useful. However, it would be difficult to justify the drilling of gravity "high" in the ocean without additional supporting geophysical data. There are many causes for gravity highs, very few of which are massive sulfide deposits.

The use of some of the more recently developed systems such as INPUT<sup>R</sup>, AFMag, and VLF might have some application over salt water in highly favorable geologic environments. These have not yet been tried along the Maine coast but some testing is anticipated in the near future.

Exploration on land is costly. Exploration of the offshore would be prohibitively costly except perhaps in areas adjacent to known mineralization or along underwater strike extensions of favorable geologic units.

### SUMMARY

The Penobscot Mine on the Maine coast has encountered many problems related to the proximity of the ocean. These problems are not insurmountable, but they add considerably to the cost of mining. As highly popular multiple-use areas, the coast will challenge the skills of mining companies to operate at a profit and yet co-exist with the environment. As exploration techniques improve and deposits are located further from shore, the challenges will become greater. Actual mining of the ore will be one of the lesser engineering problems. A major

challenge will be to develop a system which does not adversely affect the environment.

An example of concern for the environment was shown by the Maine legislature last year in passage of a bill which prohibits all offshore commercial sand and gravel mining. It was feared that the harmful side effects would outweigh the benefits. It is entirely possible that all offshore mining in Maine could be outlawed if the Penobscot Mine, which is a highly visible example, cannot operate in a way which does not abuse the environment. The challenges and responsibilities of this small mine are great and the

results will have far-reaching effect. So far, the results look promising.

ACKNOWLEDGEMENTS

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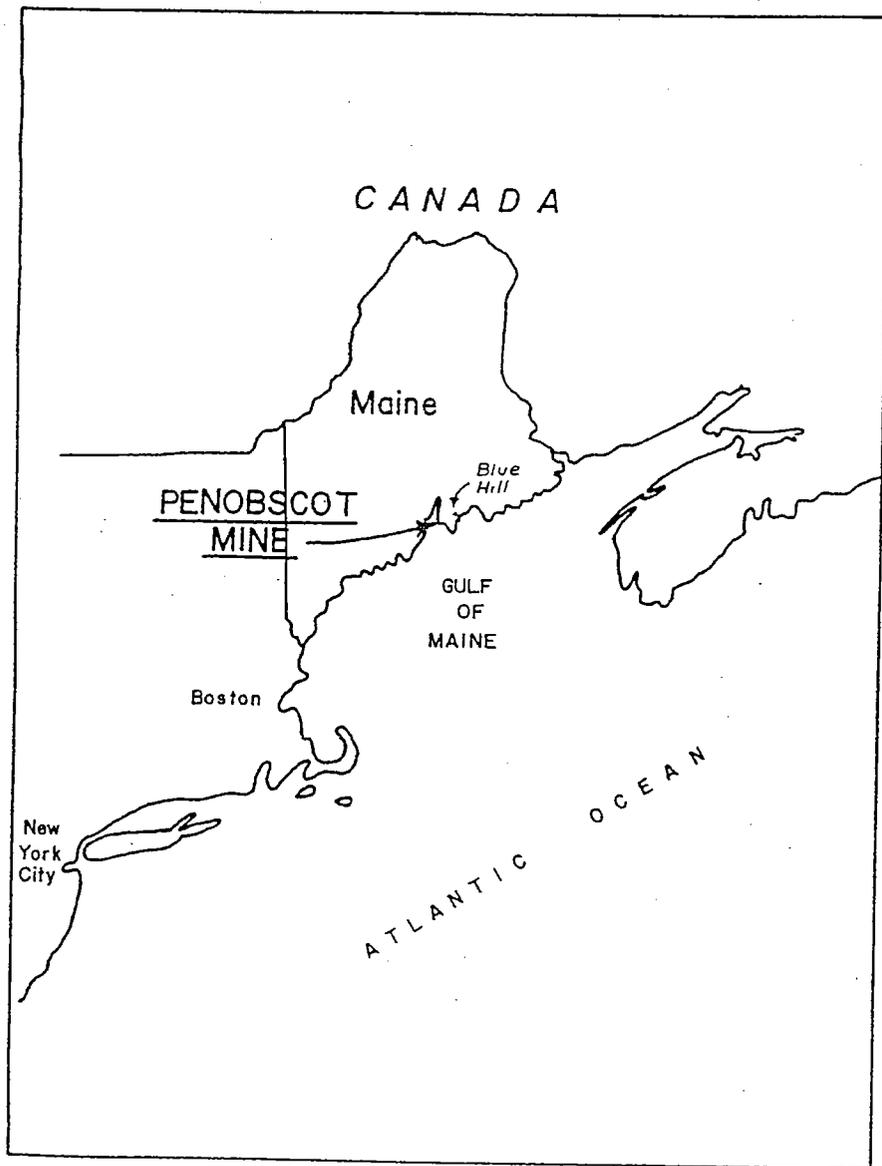


Fig. 1 - Index map, scale 1 in. = 75 miles.

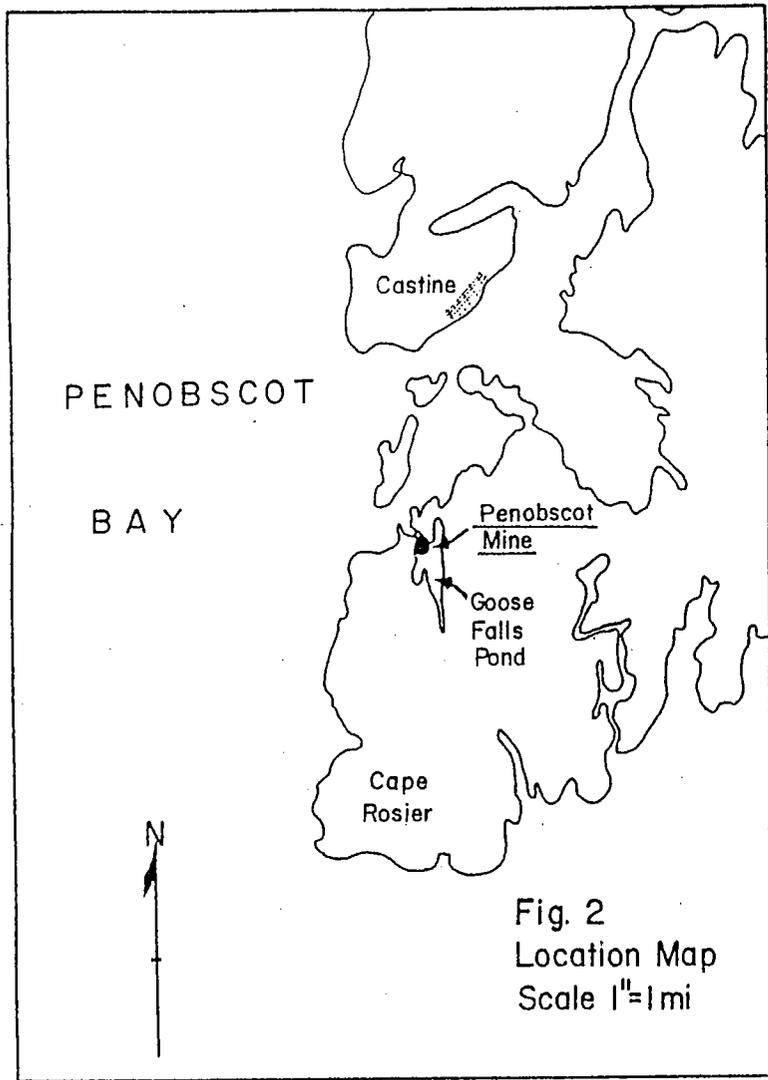


Fig. 2 - Location map, scale 1 in. = 1 mile.

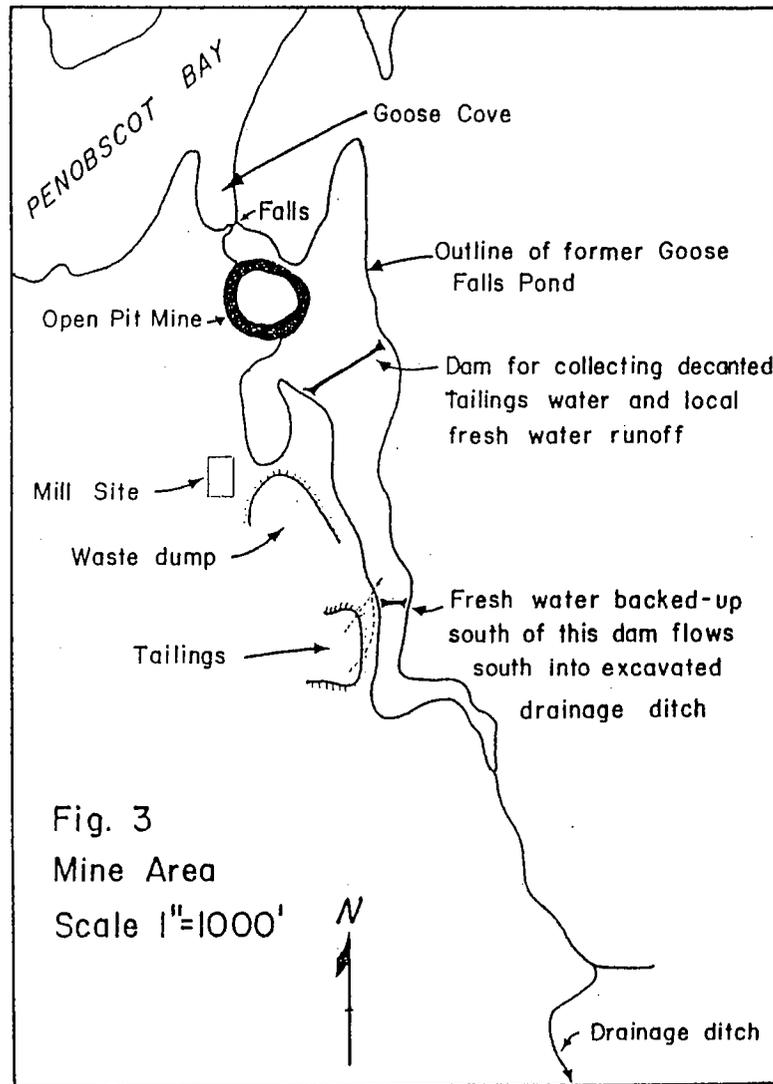


Fig. 3 - Mine area, scale 1 in. - 1,000 ft.