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# PACIFIC BENTONITE LTD.

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## HAT CREEK BENTONITE

Our company has registered claims on a large bentonite deposit in British Columbia, Canada. It is located in Hat Creek roughly 200 km northeast of Vancouver, close to road and rail transportation to the coast. The site is at elevation roughly 1000 m, and the area is semi-desert.

Over 4000 m of cored drillholes have established a minimum of 30 million tonnes of mineable clay. A large trial excavation is open for inspection. Very little overburden needs to be excavated, so that the clay can be mined by conventional open pit, truck and shovel operations, although we are also investigating mining by hydraulic monitoring. Kiln drying facilities are available in a nearby lime plant.

Mineralogical testing is currently being carried out for us by the University of Western Ontario. The clay has been characterized as near pure smectite, the major cations being sodium, magnesium and calcium approximately 20, 18, 35 meq/100 g respectively, and a total CEC in the range of 60 to 80. Recent work has shown that the clay can be soda activated very easily.

The clay should therefore find use either in the absorbent markets, or as an active clay in the drilling, foundry, pelletizing and civil engineering fields. Pacific Rim markets are attractive, but in addition our enquiries have indicated that cheap bulk shipments can be made out of Vancouver to the eastern U.S. and Europe via the Panama Canal.

We have prepared a business plan, and geology/mineralogy reports. We are seeking joint venture partners with a view to developing the prospect into a mine. If you are further interested, please contact Nigel Skermer, P.Eng., preferably by FAX 604-687-5532.

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(13)

BRITISH COLUMBIA HYDRO AND POWER AUTHORITY

092I NW084
Pacific Bentonite

DISCUSSION DRAFT ONLY

also 92I 1

# HAT CREEK PROJECT

# DETAILED ENVIRONMENTAL STUDIES

# MINERALS AND PETROLEUM

Is this the same as Hat Creek Clay (with the coal occurrence 92I NW 047

May 1978

GENERATION PLANNING DEPARTMENT

SYSTEM ENGINEERING DIVISION

EIS - 1981

5.5 LIMESTONE - (Cont'd)

feed, dust abatement in coal mines, sulphite pulp manufacture, hypochlorite bleach manufacture and water treatment.

TABLE 5-4

ANALYSES OF LIMESTONE FROM HOUTH MEADOWS

| Site | MgO(%) | CaO(%) | $Fe_2O_3$(%) | $SiO_2$ | LOI(%)* | $CaCO_3$ equiv.(%) |
|---|---|---|---|---|---|---|
| HC-3 | 1.92 | 52.50 | 0.08 | 3.25 | 42.28 | 93.71 |
| HC-5 | 1.40 | 53.60 | 0.08 | 2.15 | 42.58 | 95.68 |
| HC-7 | 1.65 | 53.90 | 0.06 | 0.45 | 43.90 | 96.21 |
| HC-13 | 1.38 | 54.40 | 0.05 | 0.35 | 43.25 | 97.10 |

* LOI means "loss on ignition".

(c) Present Situation

Potential reserves of limestone in the vicinity of the Hat Creek Valley are very large. Limestone is currently being mined by Steel Brothers Canada Limited in Marble Canyon. Lime is produced at the plant which has a rated capacity of 320 tonnes (350 short tons) per day.[51] The lime is used principally as a fluxing agent by nearby mine mills and pulp mills. Present demand by the pulp, paper and copper industries is low, therefore the plant is not operating at peak capacity.

5.6 CLAYSTONE DEPOSITS

(a) Introduction

Unlithified claystone and siltstone comprise an appreciable thickness of the Medicine Creek and Hat Creek Coal formations

SEE ALSO CLAY & SHALE VOL. II

inter-office memo

MEMO TO: M. A. FAVELL

14 February 1978

FROM: P. T. McCULLOUGH

File: 1301.2
213.1

SUBJECT: Progress Into the Uses of Coal By-Products From Hat Creek

Five studies are examining the uses of coal by-products from Hat Creek:

1. Kaolin - being conducted by Drs. A. C. D. Chaklader and I. H. Warren. A bulk sample from trench B (360 kg) has been homogenized and sampled. Initial indications are that this is an exceptionally good clay with a high kaolin content and as a result a high vitrification temperature. Therefore it could produce excellent refractory material. Samples have been sent to Clayburn Industries to undergo tests which U.B.C. cannot do. Additional samples of washery rejects have been requested by Dr. Chaklader in order to determine if this material contains clay of similar quality. Completion of the tests is expected on 31 August 1978.

2. Alumina extraction - being conducted by Dr. A. Winer of the Industrial Minerals Laboratory, Ottawa. A bulk sample of laboratory rejects is being sent from Commercial Testing Ltd. The sample is from DDH 76-191 and is considered to be representative of the kaolinitic clays. The extraction of alumina from the clay will be examined and compared with extraction of alumina from ash produced in a fluidized bed system being constructed at EMR. In addition Dr. Winer has received two samples of bentonitic clay, one from DDH 76-126 and the other from trench A. He will examine the cation exchange capacity of the clay and its potential as a source of bentonite. The completion date is unknown.

3. Bentonite - being conducted by [redacted] is interested in bentonite throughout Canada. They are currently examining data collected from B. C. Hydro in order to devise a sampling program to examine the bentonitic clays from Hat Creek. The completion date is uncertain, but it is expected to finish by 30 June 1978.

4. Baked clay - being conducted by Clayburn Industries Ltd. Four channel samples were collected from trench A at Hat Creek. Initial indications are that the material is a good substitute for artificially calcined clay. Results are expected within the next week.

...2

FORM 91908(8/72)

5.6 CLAYSTONE DEPOSITS - (Cont'd)

in the Upper Hat Creek Valley. These formations underlie approximately 109 $km^2$ (42 sq mi) of the valley. Large quantities of these materials would be excavated from a coal mine at Hat Creek.

The method of studying the effect of the proposed Hat Creek Project on the utilization of these claystone resources has been to define the distribution of these rocks based on existing drill cores and drill logs and to quantitatively determine their mineralogy. In the next phase of studies it will be necessary to determine other properties and market factors which could influence their use.

The procedure for quantitative determination of the mineralogy of the claystones involved X-ray diffraction scans and integration of photon counts over the diffractometric peaks. To obtain these peaks the raw samples were first pulverized and homogenized. An X-ray diffraction scan was made between 3 degrees and 95 degrees of 2-theta for all samples. Some glycolated samples were analyzed to differentiate between illite and montmorillonite (bentonite). Attempts were made to identify all of the peaks on the diffractogram. Standard calibration curves were made using synthetic mixtures containing known quantities of minerals identified in the clay samples. An internal standard of 10 percent by weight of magnesia was used for all samples. The photon counts over one peak of each of the minerals was normalized and integrated with respect to the integrated peak density of magnesia. The areas under the curves are proportional to the quantity of that mineral in the rock; therefore the amount of each mineral in the clay sample could be determined.[13,14,15] The estimation of minerals by this technique is considered accurate within ±3 percent for feldspar, quartz and kaolinite and within ±5 percent for bentonite. The following minerals were also checked if they were found: pyrophyllite, serpentine, halloysite, dolomite, calcite, siderite, ankerite, goyazite, apatite, gypsum, magnetite, pyrite, galena, sphalerite, tetrahedrite, chalcopyrite, hyalophane and epidote.

In addition to these quantitative analyses, X-ray diffraction studies were conducted by Dr. R.M. Quigley of the University of Western Ontario[27] and Dr. P.A. Hill of Carleton University[30] on a large number of samples. The purpose of these latter studies was to determine the cause of certain geotechnical properties of the rocks; however information on the clay as a potential resource was collected simultaneously.

Once the types and distribution of the minerals have been examined it is planned to investigate any potentially marketable clay minerals. The investigation of kaolinite extraction is to be undertaken by Dr. A.C.D. Chaklader and Dr. I.H. Warren of the University of British Columbia. The properties of the kaolinite and their relationship to the following uses will be investigated:

1. Production of mullite and alumina for making high temperature refractory brick or as a feedstock to an aluminum smelter.

2. Production of alumino-silicate catalysts for the petroleum industry.

3. Production of tricalcium aluminate for cement.

4. Production of ceramic-products using kaolinite and bentonitic claystones.

5.6 CLAYSTONE DEPOSITS - (Cont'd)

The results of these studies are expected in September 1978.

Another study is to be conducted in Ottawa by Dr. A. Winer of the Canada Centre for Mineral and Energy Technology. The study will determine the properties of the kaolinitic claystone for use in alumina production and the properties of the bentonitic claystone and its potential uses. The former study will involve a determination of the amount of alumina that can be extracted; the methods are described in the environmental report on "Solid Waste Disposal Coal Storage Land Reclamation". The latter study will examine the cation exchange capacity and the nature of the exchangeable cation in the bentonite. The determination involves an ammonium acetate cation extraction, filtration, ammonia distillation into sulphuric acid, and back titration with sodium hydroxide to determine the amount of the ammonium radical ($NH_4^+$) that has replaced the exchangeable cation. The sodium and calcium concentrations in the filtrate are determined by atomic absorption. Considerable care must be taken in sampling to avoid contamination by sodium bentonite from the drilling mud. These studies will also examine the ash from fluidized bed combustion tests to determine if these by-products could be used as a source of alumina.

In addition, several aluminum companies were approached as a result of the Preliminary Environmental Study on Hat Creek.[21] The Preliminary Environmental Study noted that aluminum companies may be interested in clay (and/or fly ash) as a source of alumina. Some analyses of alumina were completed by the Aluminum Company of America Inc. (Alcoa)[47] and Alcan International (1975) Ltd. (Alcan).[48] A total of 15 169 m (49 754 ft) of ash from Hat Creek drill core has been analyzed for alumina as part of the standard

5.6 CLAYSTONE DEPOSITS - (Cont'd)

mineral analysis. The total aluminum in the ash, expressed as aluminum oxide ($Al_2O_3$), has been summarized by coal zone in histograms.

(b) Current uses of Clay

Clay for industrial use is divided into several different types based on mineralogy and properties which relate to its potential end use.[4] China clay (kaolin) is white, consists primarily of kaolinite and has a high fusion temperature. Ball clay is plastic, white-firing and consists of kaolinite, sericite and some organic matter. Fire clay is plastic or rock-like and consists of kaolinite with some diaspore, bauxite clay, shale, ball clay, burley and burley flint. Bentonite consists primarily of montmorillonite; the clay is divided into the swelling or sodium-type and the nonswelling or calcium-type; the former will swell as much as 15 or 20 times its dry volume. Fuller's earth is a non-plastic clay-like material with adequate decolourizing and purifying properties; the material is composed of attapulgite or montmorillonite with or without opaline silica. Common clay is a plastic clay or clay-like material which can be readily moulded and which vitrifies below 1100°C; it usually consists of kaolinite, illite, chlorite and montmorillonite. Common clay is usually higher in alkalies and ferruginous minerals and lower in aluminum than the kaolins, ball clays and fire clays.

Clay resources in the world are very large. However most countries, although they may have adequate supplies of some clay types, generally do not have the specialty clays. The United States is an exception in that it has large reserves of all types of clay. Canadian imports of clay are listed in Table 5-5a. Although Canada is the fourth largest producer of clay,[4] principally common clay and fire clay, this production is concentrated

5.6 CLAYSTONE DEPOSITS - (Cont'd)

in the east; there are only a few small plants in western Canada. Few known deposits of fire clay or ball clay are being utilized. In 1975 Canada imported 257 000 tonnes (283,000 short tons) of bentonite and more than 148 000 tonnes (164,000 short tons) of kaolin.[64]

The degree of processing of the natural clay depends on its quality and the value of the clay for a particular end use. Principal processing methods range from simple crushing of common clay or shale for most structural clay products and refractory cement to a combination of several techniques for specialized kaolin clays including crushing, blunging, sedimentation, water fractionation, ultraflotation, acid treatment, calcination, air floating, attrition grinding and delaminating.

Because of the scarcity of specific types of materials, principally china clay, refractory fire clay and bentonite, these materials can be mined, processed and transported a considerable distance. Mining costs for clays range from $1.00 to over $10.00 per tonne. Processing costs can range from a few cents per tonne for common clays to over $100.00 per tonne for special paper coating and high quality clays.

The amount of clay consumed particularly for cement and for brick manufacture is very large. A summary of demand in the United States by clay type and a forecast of clay demand in the year 2000 are listed in Table 5-5b.[4] The demand is increasing at an average rate of approximately 4 percent per year.

The uses of clays are dictated mainly by local markets; however there are a few exceptions. The types of clay used depends

5.6 CLAYSTONE DEPOSITS - (Cont'd)

on the availability, cost and properties of the clay. Approximately 40 percent of the clay consumed in the United States in 1975 was common clay and shale for use in building bricks, drain tile, vitrified sewer pipe and a number of other construction materials. Twenty percent of the clay was used in the manufacture of Portland cement; this was primarily common clay and shale.

TABLE 5-5a

CANADIAN IMPORTS IN 1975 BY TYPE OF CLAY
(in thousands)

| | Tonnes | Short Tons |
|---|---|---|
| Kaolin | 148 | 164 |
| Fire Clay | 43 | 48 |
| Bentonite and Drilling Mud | 257 | 283 |
| Activated Clay (Fuller's Earth) | 44 | 48 |
| Other Clays | 137 | 151 |

TABLE 5-5b

U.S. DEMAND IN 1973 AND DEMAND
FORECAST FOR THE YEAR 2000 BY TYPE OF CLAY
(in thousands)

| Type | 1973 | | 2000* | |
|---|---|---|---|---|
| | Tonnes | Short Tons | Tonnes | Short Tons |
| Kaolin | 4 803 | 5,295 | 20 000 | 22,000 |
| Ball Clay | 604 | 666 | 3 000 | 3,000 |
| Fire Clay | 3 513 | 3,872 | 15 000 | 16,000 |
| Bentonite | 2 288 | 2,522 | 6 000 | 7,000 |
| Fuller's Earth | 980 | 1,080 | 5 000 | 5,000 |
| Common Clay | 44 756 | 49,335 | 116 000 | 128,000 |
| Total | 56 944 | 62,770 | 165 000 | 181,000 |

* Numbers are rounded to the nearest thousand.

Approximately 15 percent of the clay was used in making lightweight concrete floors and walls because clay provides better insulation than sand and gravel aggregate; these clays were predominantly common clay or shale. Approximately 10 percent of the clays was fire clay for use in refractories. Kaolin for paper filler and coater filler in cosmetics, fine china, refractories, plastics, etc. accounted for approximately 4 percent of U.S. consumption. About 10 to 11 percent of the clay consisted of bentonite, common clay, ball clay, kaolin and Fuller's earth for miscellaneous special uses such as drilling mud, iron ore pelletizing, pottery and ceramic ware, and as a decolourizer or purifier.

(c) Inventory

Studies were conducted on rock samples from the Hat Creek Valley to determine the types of clay and their distribution in the No. 1 deposit. This information is essential in order to examine the potential use of the claystone. The claystone in the hanging wall and in the upper half of the coal measures contains appreciable bentonite. The lower half of the coal measures contains predominantly kaolinite both as inherent mineral matter in the coal and as partings as much as 9.4 m (31 ft) or more thick.

Within the lacustrine beds above the coal, bentonite predominates over kaolinite with the sampling distribution skewed toward the less-bentonite end (Figure 5-5). The samples from the A coal zone are generally lower in bentonite, but the distribution is skewed toward the more-bentonite end. Samples from the B, C and D coal zones have low bentonite; most exceptions are associated with the "shale out" on the west side of the deposit. The distribution of clay minerals from below the coal (foot wall) is irregular, but the samples are generally low in bentonite.

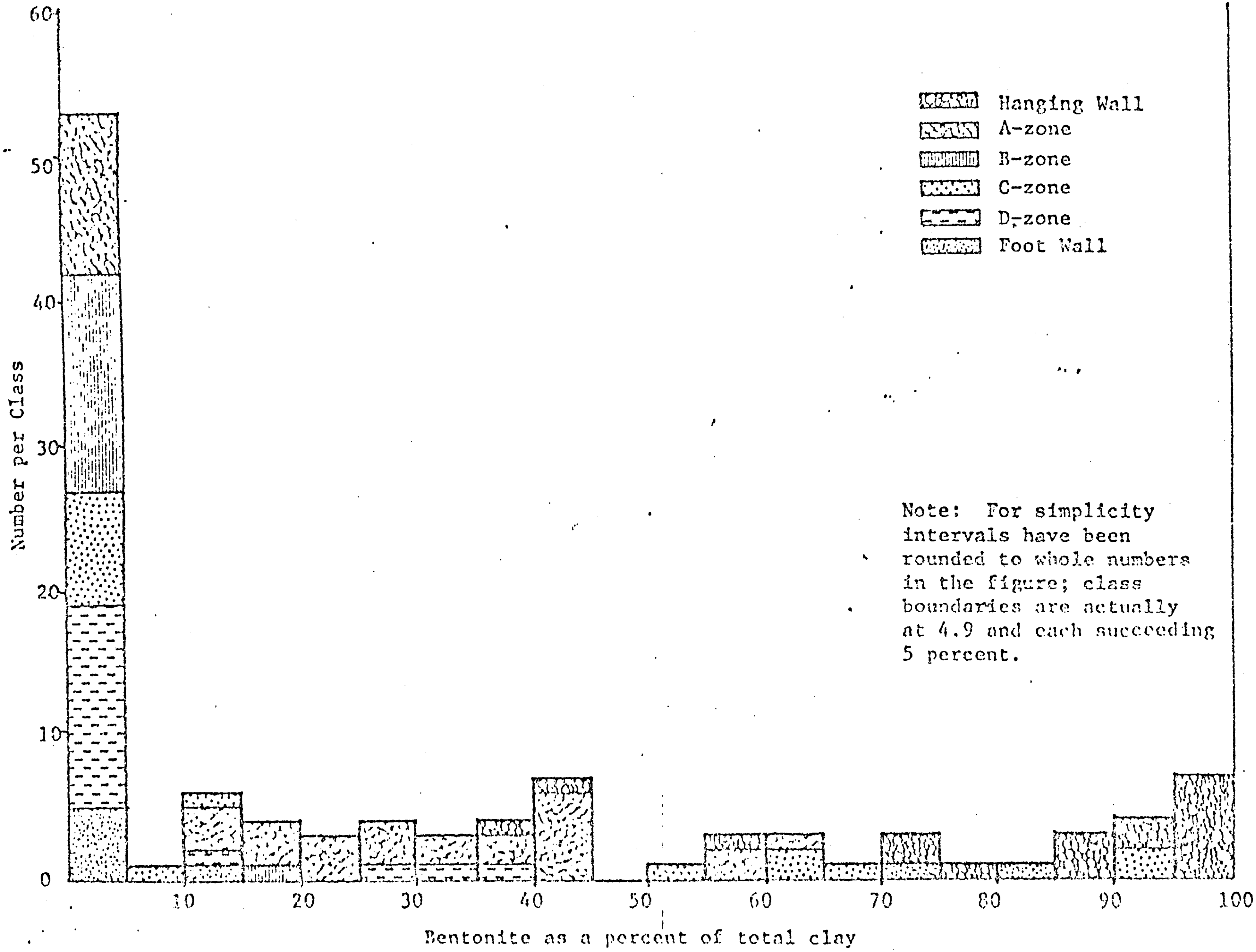



Figure 5-5 DISTRIBUTION OF CLAY MINERALS BY ZONE

## 5.6 CLAYSTONE DEPOSITS - (Cont'd)

Figures 5-6 through 5-9 illustrate the variation of the dominant minerals in the coal measures and adjacent rocks. These histograms were constructed for quartz, kaolinite, bentonite and feldspar from the hanging wall, foot wall and coal zones A, B, C and D. Within the coal zones most of the samples are from carbonaceous or coaly intervals because totally noncarbonaceous intervals are rare. The quartz content increases from the hanging wall through B zone; C and D zones and the foot wall have wide distributions in quartz content (Figures 5-6a through 5-6f). The concentration of kaolinite is related inversely to the concentration of bentonite (Figures 5-7 and 5-8). The kaolinite content is low in the hanging wall and increases through A, B and D zones. C zone has a wide distribution with numerous samples low in kaolinite; as described above, these are related to the "shale out" on the west side of the No. 1 deposit. The samples from the foot wall seldom contain appreciable bentonite; the distribution of kaolinite is scattered. The feldspar content is commonly low with samples from C zone having the most variation (Figure 5-9). The samples commonly have only trace amounts, if any, of epidote, siderite, calcite, ankerite and pyrite; in a few samples these constitute major mineral phases of the rock.

The remainder of the Upper Hat Creek Valley, outside of the No. 1 deposit, contains appreciable claystone with a mineralogical distribution which is probably similar to that in the No. 1 deposit.

Investigations to begin early in 1978 are expected to indicate if kaolinite can be extracted and to determine the properties of this kaolinite. In addition it is planned to examine the nature of the exchangeable cation in the bentonite. These programs will determine possible uses for the kaolinitic and the bentonitic claystones.

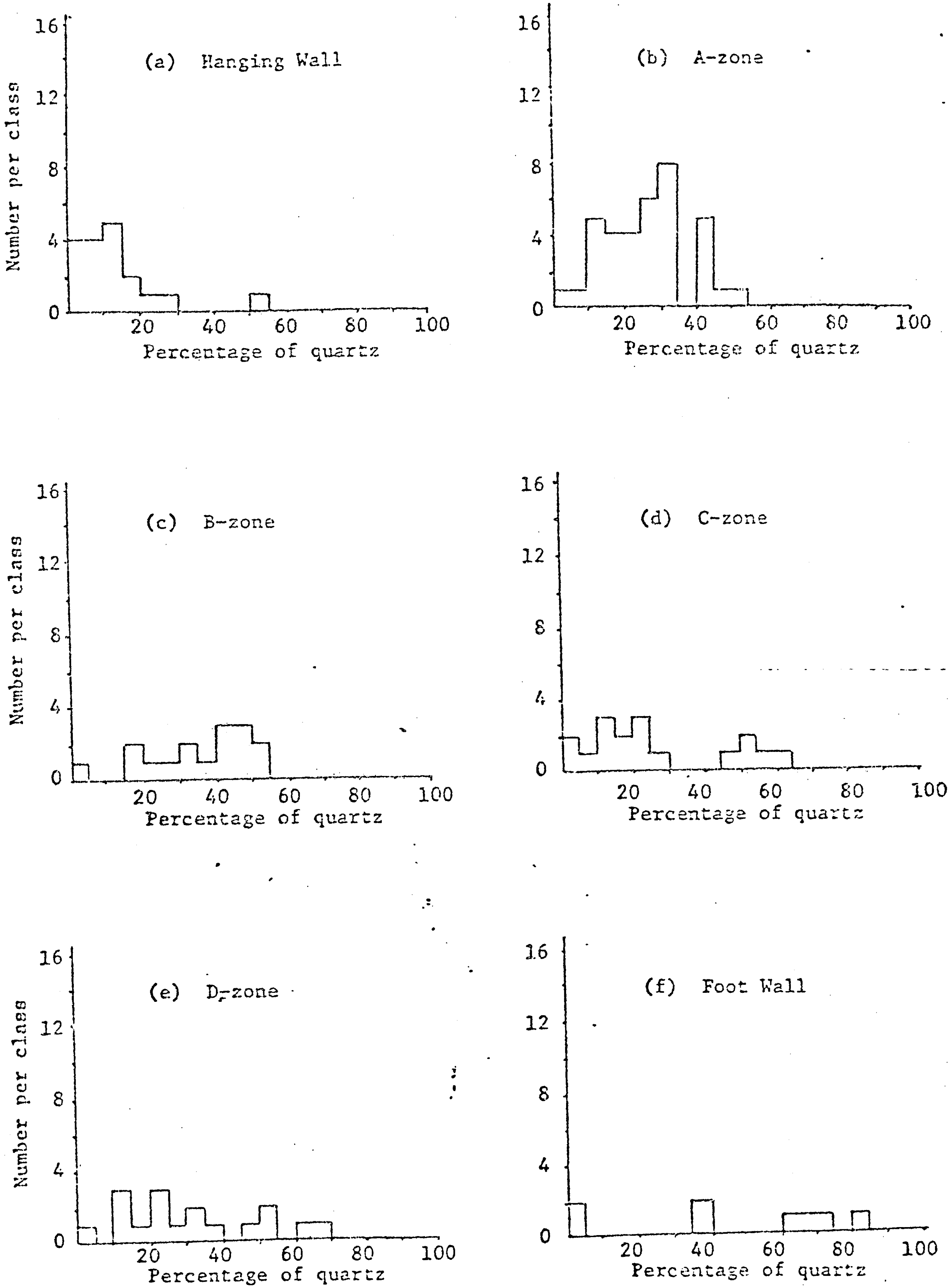



Figure 5-6 Histograms illustrating the distribution of quartz in each zone.

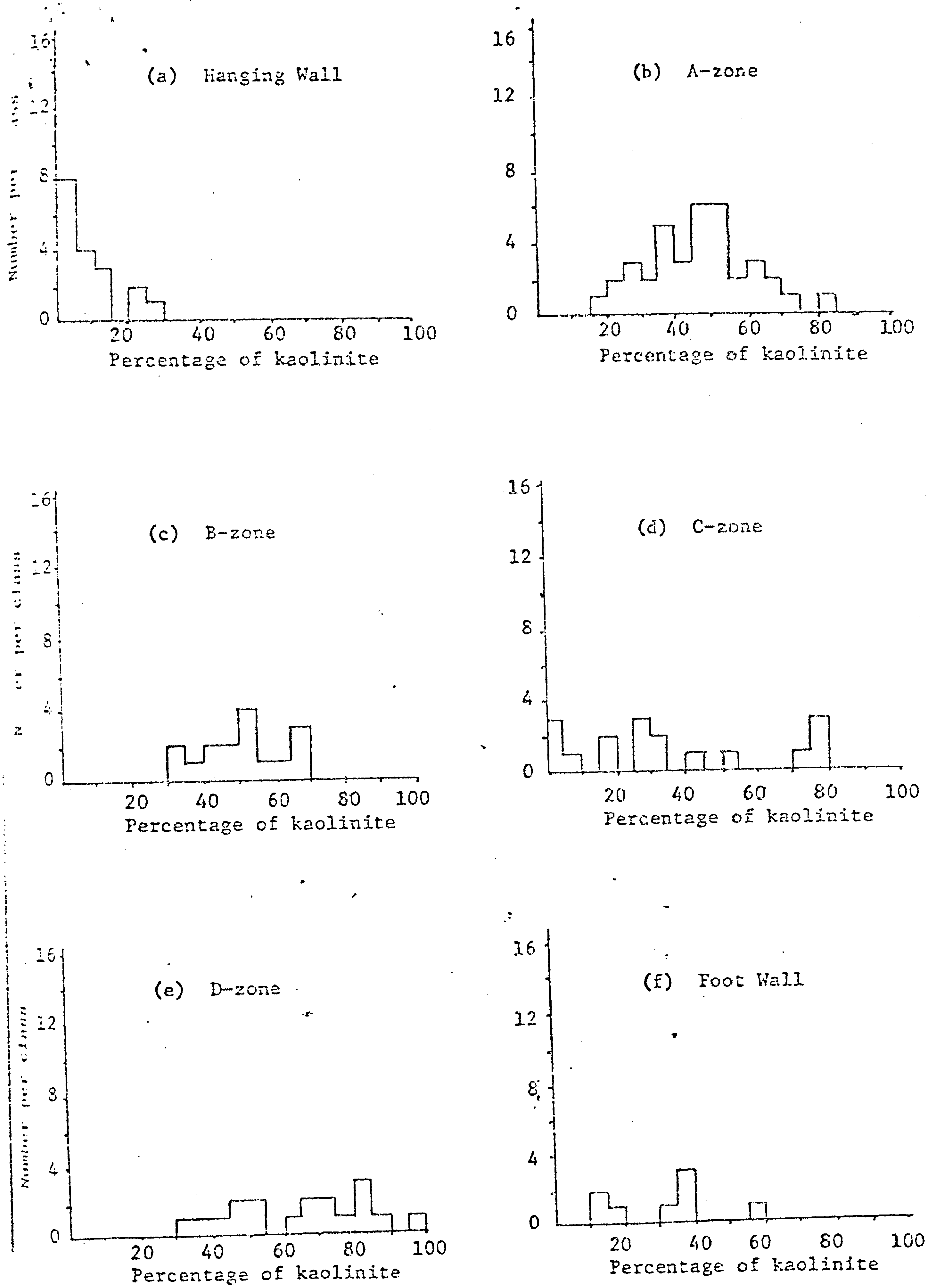



Figure 5-7 Histograms illustrating the distribution of kaolinite in each zone.

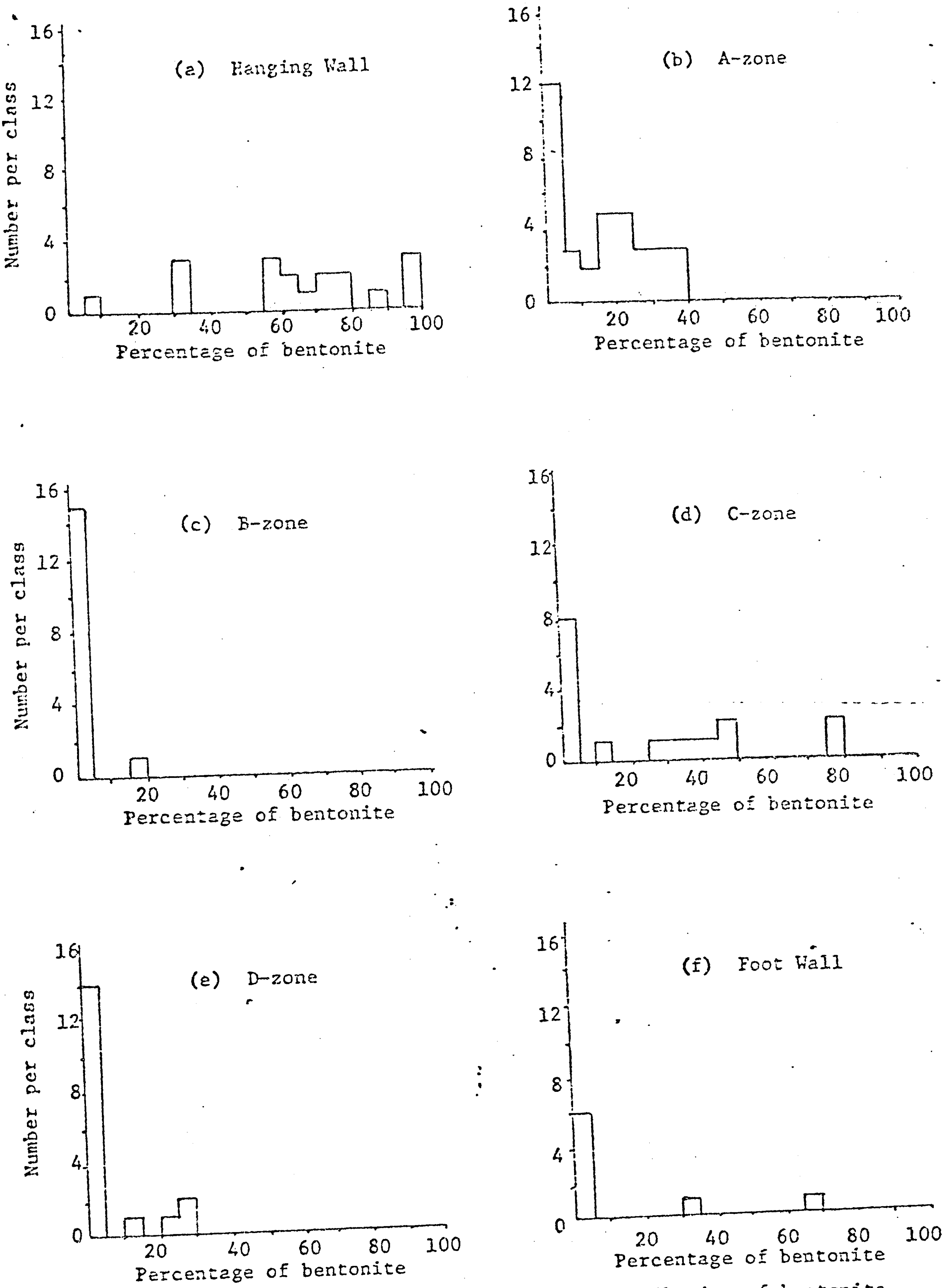



Figure 5-8 Histograms illustrating the distribution of bentonite in each zone.

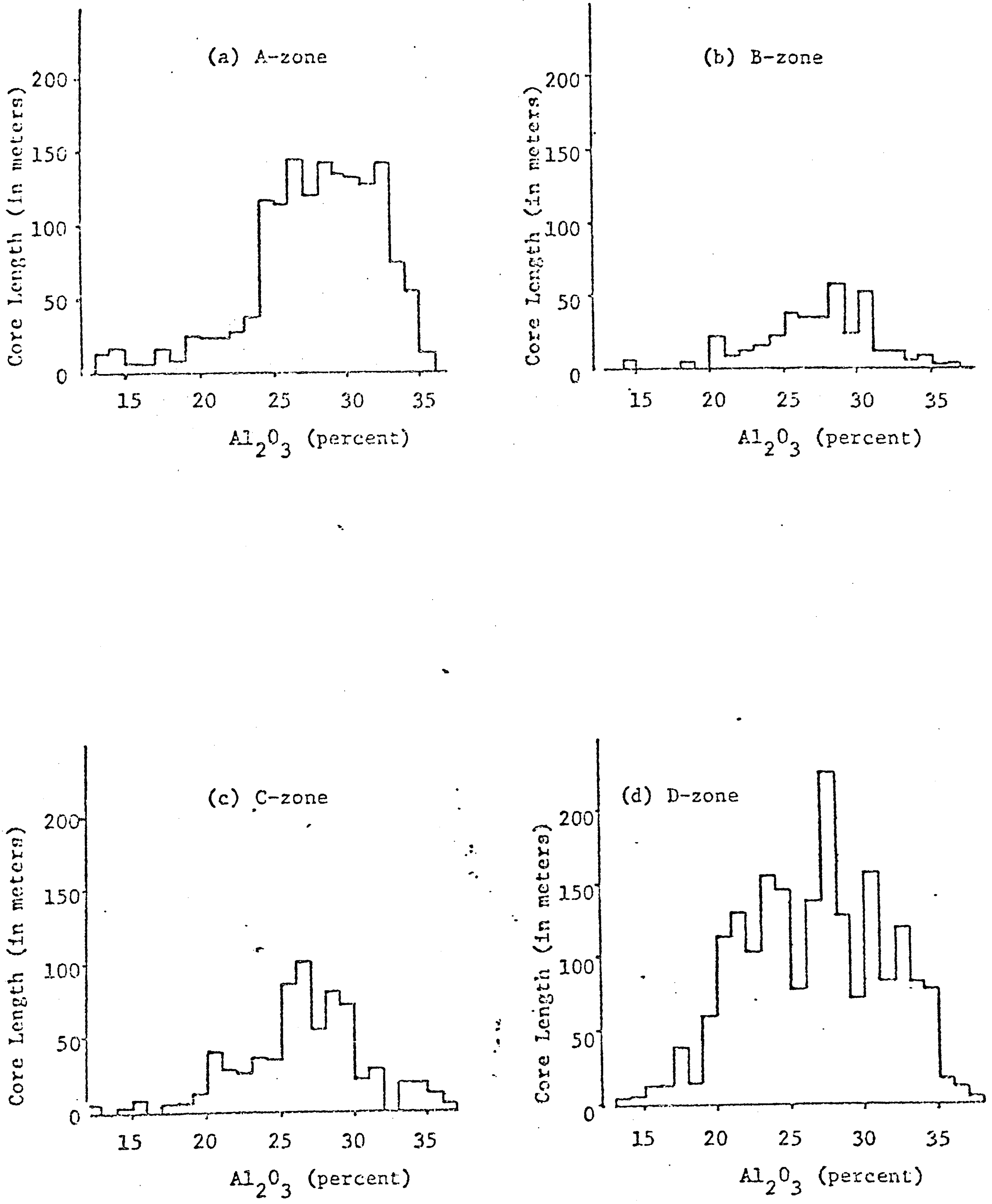


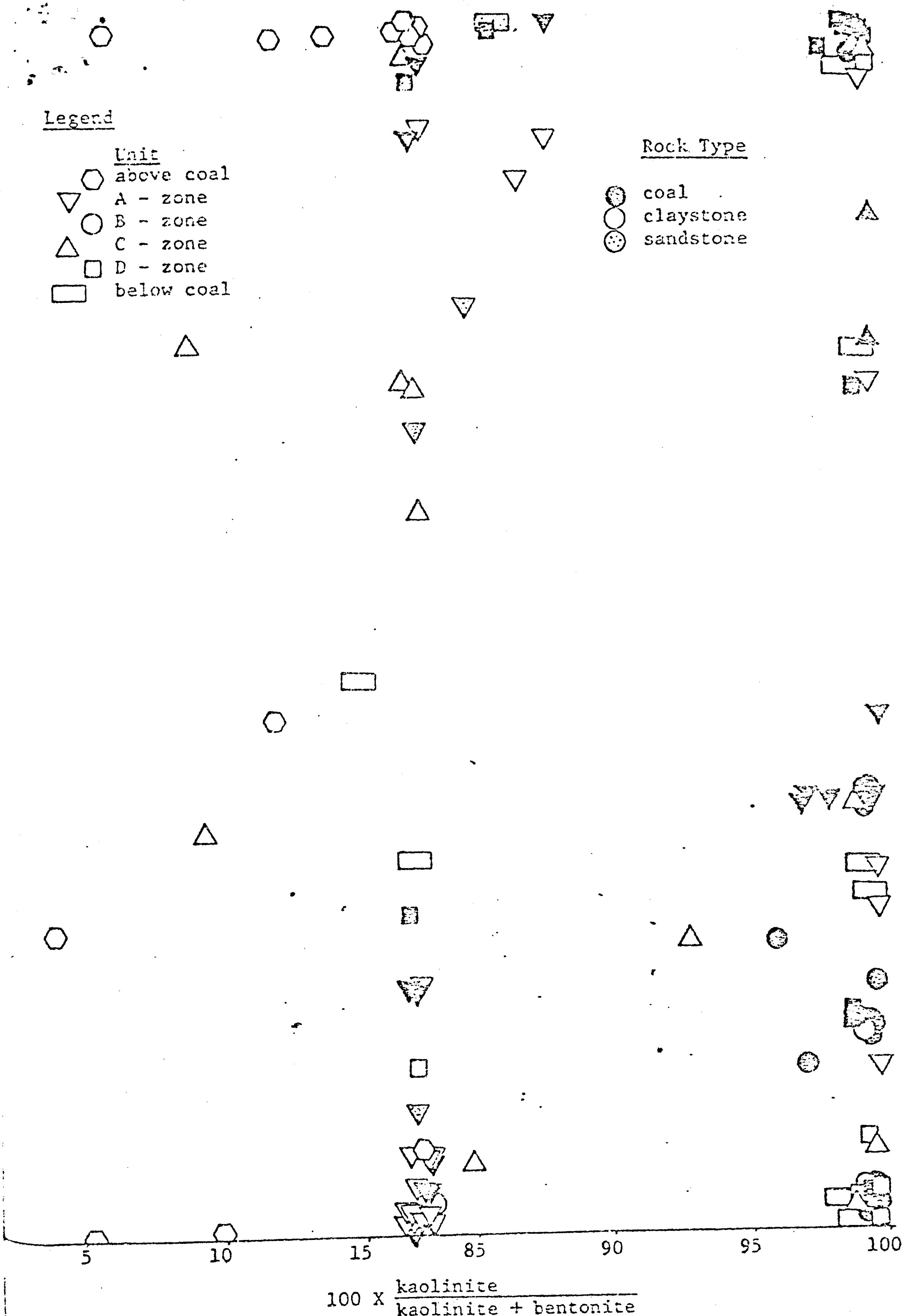

Figure 5-10 DISTRIBUTION OF ALUMINA BY ZONE

5.6 CLAYSTONE DEPOSITS - (Cont'd)

The Preliminary Environmental Impact Study for the proposed Hat Creek development noted that aluminum companies may be interested in clay (and/or fly ash) from Hat Creek as a source of alumina. Before the distribution of the types of clay in the deposit was appreciated, samples were examined by the Aluminum Company of America (Alcoa)[48] and Alcan International (1975) Ltd. (Alcan).[47] The results of these analyses are summarized in Table 5-6. The analyses indicate very low alumina in the hanging wall claystone whereas samples from the coal zones contain more alumina. Of the $Al_2O_3$ in sample 74-37A:1160-1290, the alumina extractable by an acid leach is approximately 80 percent of the total. A summary of the distribution of $Al_2O_3$ among each of the four coal zones is illustrated in Figure 5-10. The concentrations of $Al_2O_3$ in the ash have a broad range; however they are generally between 25 and 30 percent. The alumina is enriched in the more kaolinitic intervals of the claystone and siltstone sections and depleted on the west side of the No. 1 deposit and in the sandstone horizons. A plot of the kaolinite-bentonite ratio versus parting thickness is illustrated in Figure 5-11. The purpose of this plot was to determine if selective mining would be possible in some of the areas containing appreciable kaolinite. Of the 24 samples of kaolinitic claystone that were examined, thirteen are from partings greater than 1.5 m (5 ft) thick and seven of these are over 6 m (20 ft) thick. Based on this preliminary information some selective mining could be practical; studies into the uses of these clays are continuing.



A more detailed examination of the feasibility of extracting alumina from mine and plant wastes (claystone and fly ash) is included in the section of the Hat Creek Detailed Environmental Study entitled "Solid Waste Disposal Coal Storage Land Reclamation".




5 - 11 Kaolinite-bentonite ratio versus parting thickness.

## 5.6 CLAYSTONE DEPOSITS - (Cont'd)

### (d) Present Situation

Claystone and siltstone deposits underlie much of the Upper Hat Creek Valley. In addition they are interbedded with the coal sequence, particularly in A and C zones.

TABLE 5-6

ANALYSES FOR ALUMINA IN CLAY SAMPLES FROM THE UPPER HAT CREEK VALLEY

| Hole No.: | Interval (in feet) | Zone | $Al_2O_3$ (%) in Dry Ash |
|---|---|---|---|
| 74-37A: | 270 - 430 | H.W.* | 16.79 |
| 74-26: | 830 - 1020 | H.W. | 16.84 |
| 74-37A: | 1160 - 1290 | A | 20.59 |
| 74-46: | 562 - 582 | C | 29.5 |
| 74-46: | 670 - 690 | C | 24.8 |
| 74-46: | 774 - 802 | C | 26.8 |
| 74-46: | 831 - 851 | C | 28.7 |
| 74-46: | 956 - 986 | C | 26.1 |
| 74-46: | 986 - 1026 | D | 30.4 |
| 74-46: | 1106 - 1146 | D | 28.8 |
| 74-46: | 1528 - 1540.5 | D | 26.8 |
| 74-106: | 1490 - 1835 | D | 29.3 |

* H.W. is an abbreviation for the hanging wall lacustrine sedimentary rocks overlying the coal sequence.

No clay has been mined previously in the Upper Hat Creek Valley. The demand for clay depends on marketability based on mining, processing and transportation costs as well as the acceptability of the product. The Hat Creek area is isolated from the Lower Mainland where most of the demand for clay products is centered. The cost of exclusively mining the more kaolinitic clays would involve considerable stripping plus the separation of coal and bentonitic beds. The cost could not be justified under

5.6 CLAYSTONE DEPOSITS - (Cont'd)

present conditions where neither the coal nor the bentonitic beds could be sold and where the total cost of mining and transportation must be borne by the kaolinitic clay.

(c) Present Situation

In the summer of 1977 a trench was excavated to extract coal for a test burn at the Battle River Powerplant of Alberta Power Company. During excavation of this trench roads were constructed from the baked claystone. The material was found to be useful for that purpose; the baked claystone road material remained relatively dry and the road surface was not slippery even after heavy rains. Similar baked claystones are used elsewhere in place of aggregate for gravel roads.