Supergene weathering at the Crandon deposit. 1982

Rowe, Roger G.
[Place of publication not identified]: [publisher not identified], 1982

SUPERGENE WEATHERING
AT THE
CRANDON DEPOSIT

SUPERGENE WEATHERING
AT THE
CRANDON DEPOSIT

by

Roger G. Rowe

April, 1982

SUPERGENE WEATHERING AT THE

CRANDON DEPOSIT

FIGURES
(in order at end of text)

PLATES
(in plastic sheets at end of report)

Plate No. Strength of Weathering

INTRODUCTION

Weathering is the destructive process or group of processes causing the physical disintegration and chemical decomposition of bedrock. The agent of destruction is circulating descending groundwater, commonly containing atmospheric oxygen.

At the Crandon deposit, the weathering effects observed have been taking place for millions of years, perhaps since Precambrian time, when the entire area was uplifted into a high mountain range. Continuing weathering since that time has slowly destroyed the mountains grain by grain, until they were leveled to a relatively flat area, as we see today. About 20,000 years ago, the area was overridden by a continental glacier sheet, which scraped much of the softer weathered rock away. It is likely that the glacier stripped about 50 feet of soft, weathered rock off the deposit before it encountered weathered rock which was hard enough to not be eroded by glacial action. The in situ weathered rock which we observe today is almost exactly what it was like when the glaciers retreated. Since weathering is a slow process, it is likely to have penetrated only an inch or two deeper since the glaciers retreated approximately 10,000 years ago.

WEATHERING PROCESSES

In describing the weathered rocks at Crandon, the drill core was evaluated with respect to the destructive processes of oxidation, leaching, argillization (pervasive clay development) and fracture intensity. The extent to which each destructive process has affected the drill core was measured in relative intensity.

Destructive Processes

Oxidation	Total:	Total oxidation of all sulfides.
	Partial:	Partial oxidation of all sulfides.
	Trace:	Traces or small quantities of transported and/or indigenous limonite on fractures or bedding planes.
Leaching	Strong:	>5 volume percent secondary porosity.
	Moderate:	2-5 volume percent secondary porosity.
	Weak:	Trace-1 volume percent secondary pososity.
Argillization	Strong:	Pervasive strong development of clay. Rock soft and breaks easily. (Rock easily gouges with nail.)
	Weak:	Weak or partial clay development, but rock doesn't break easily.
Practuring	Strong:	>20 fractures/foot.
	Moderate:	5-20 fractures/foot.
	Weak:	1-4 fractures/foot.

After each of the destructive processes are evaluated and rated for a specified interval of core, an overall rating of weathering intensity is given which reflects the severity of all the destructive processes combined:

Weathering Intensity Rating

Strong:	Strong development of two or more of the destructive processes. Rocks will have very low compressive strengths and workings would have to be supported at all times (that is, assuming they can be entered at all).

Moderate: Strong development of one of the destructive processes (or moderate development of two) and weak to moderate development of at least one more. Rocks may or may not be strong enough to hold a back, depending upon which destructive processes have been active. Strong development of argillization or fracturing would make the rock very weak or unstable, whereas strong development of oxidation or leaching may not seriously affect its ability to hold a back.

Low: Moderate leaching with only minor other effects. The compressive strength of the rock is not seriously reduced.

Weak: Weak development of leaching and/or oxidation. Rock strengths are not affected.

GENERALIZED ILLUSTRATIVE CROSS SECTION

Figure 1A is a generalized cross section illustrating a typical north-south weathering profile of Crandon deposit rocks. From this profile, basic weathering characteristics which apply throughout the deposit can be illustrated and discussed from figures 1B-1F.

The weathering profile and active destructive processes vary considerably between footwall, Crandon formation and hanging wall. This is in response to the primary chemistry of the rocks, and the physical-chemical conditions acting upon those rocks.

In discussing the generalized cross sections, it must be kept in mind that they represent basic weathering characteristics and principles applicable at this deposit. The fact is that the supergene weathering system is very complex and has many irregularities and variations from the generalized norm. While the base of the weathering zones are shown relatively smooth on the generalized section for illustrative purposes, in reality they are shaped much like the base of a molar tooth, with many root-like projections.

Two types of ore are present at the Crandon deposit. Massive ore is a zinc-rich syngenetic ore type which is contained strictly within the Crandon Unit. Stringer ore is a copper-rich epigenetic ore type which is contained within the footwall. It is important to remember that only portions of the Crandon Unit and footwall are of sufficient width and grade to be of commercial value.

Footwall

The footwall rocks follow a relatively uniform weathering pattern compared to the Crandon formation (Figure 1A). The lower boundaries of the various weathering intensities are relatively horizontal, but contain many root-like zones which penetrate deeper. The footwall weathering follows a relatively uniform pattern because the rocks are relatively uniform in composition, being siliceous in nature. The primary destructive process is leaching.

In the strongly weathered zone, strong leaching has reduced the competency of the rocks to the point where crushing and collapse has played an important role in physically breaking up the rock. The acidification of groundwater due to the breakdown of sulfide minerals has further caused the breakdown of silicate minerals, putting some into solution and altering others to clay products.

In the moderately weathered zone, leaching has not progressed to a point where rock is beginning to weaken or crumble, or clays are beginning to develop from silicates. Because there has been little chemical attack on the silicates, the rock still maintains its high original compressive strengths (generally +15,000 psi). The local root-like zones of stronger weathering, however, will be structurally weak.

Porosity-Permeability and Argillization (Figures 1B, 1C): A similar degree of porosity-permeability exists throughout the entire range (low-moderate-strong) of weathered rocks. Porosity-permeability does decrease slightly with depth, but overall, it all falls withing the "moderate" range. Leaching was much stronger near the surface, but as illustrated in figure 1c, weak argillization has also taken place. This weak development of clays clogged up some of the porosity created by leaching, reducing both porosity and permeability.

Oxidation (Figure 1D): There is very little oxidation associated with the footwall rocks. When it is present, it is usually associated with narrow fracture zones. Because of its paucity, there is no significant overall effect on the rocks.

Hypogene Mineralization (Figure 1C): All of the primary copper and zinc has been leached out of the strongly weathered zone. The quantity leached from the moderately weathered zone is highly variable, however. Generally, the upper portion is moderately leached of primary metals while the lower portions are weakly leached.

Supergene Mineralization (Figure 1F): Supergene mineralization generally is present in the upper portion of the moderately weathered zone. The thickness, distribution and grade are highly variable.

Chalcocite [Cu_2S] is the most common secondary mineral, and occurs coating pyrite or chalcopyrite. Lesser amounts of covellite [CuS], bornite [Cu_5FeS_4), digenite [Cu_9S_5], enargite [Cu_3AsS_4], and native copper are also present. Traces of the above minerals may be found throughout the moderate and low weathering zones.

Secondary copper minerals can locally be of such grade as to be economic in themselves. A bigger problem lies in the fact that, locally, the secondary copper may only occur as thin films on chalcopyrite, thus causing primary sulfide to act like secondary sulfide in the flotation circuits.

Crandon Unit

The Crandon formation weathers considerably different than either the footwall or hanging wall for several reasons:

1) Because of the high total sulfide content (75 volume percent), abundant acid can be generated by sulfide leaching.
2) Contains interbedded tuffaceous and muddy units which are very weak compared to other footwall, Crandon Unit and hanging wall rocks. Movement resulting in fracturing and shearing occurs in these units. This creates porous-permeable routes for migrating solutions.
3) Contains interbedded strongly chloritic beds which weather readily to clay in response to strong acid generation from leaching sulfides.
4) The dip of the orebody causes solutions to migrate readily down the hanging wall contact.

As a result of the above factors, the Crandon formation is more deeply weathered than the footwall (Figure 1A). The most prominent feature is a weathering "spike" along the hanging wall side of the Crandon formation, which locally may penetrate below the proposed 230 m mine level.

Porosity-Permeability and Argillization (Figures 1B, 1C): The rocks may be broken down into two major groups:

a) Massive sulfide with tuffaceous or chloritic gangue or pyritic tuffs; volumetrically makes up 60 percent of the Crandon formation.

b) Massive sulfide with highly siliceous gangue; volumetrically makes up 40 percent of the Crandon formation.

Each type reacts differently to weathering. The rocks of the first group tend to contain abundant in situ and transported clay near the surface. In situ clay develops from the breakdown of chlorite, sericite and feldspar during chemical weathering. Very close to the surface, some of this clay appears to be transported short distances, filling in available porosity. This tends to make the upper several meters less permeable than one might expect. With depth, however, less clay is produced. Since less clay is available to plug up leach porosity, the rocks are, overall, more porous and permeable.

The gossan which results from the oxidation of the chloritic massive sulfide dominantly consists of fine-grained, hydrous iron oxides of hematite, goethite and jarosite. It has a tendency to be relatively non-porous because of a lack of siliceous framework, the fine-grained texture, and interstitial clay resulting from the breakdown of minerals (feldspars, micas, chlorites, etc.).

Rocks within the second group, commonly referred to as siliceous massive sulfide, respond somewhat differently to weathering than the first group. Since the rocks consist almost entirely of sulfide and quartz, very little clay is produced by the weathering process. Leaching is the dominant destructive agent. First, sphalerite leaches out, followed by quartz going into solution. The resulting rock is highly porous and permeable. Near the surface, the sulfide is commonly oxidized, producing a highly siliceous, cellular iron oxide boxwork, which is very porous and permeable. Within a few meters of the subcrop, this gossan appears to contain some clay. Much of this is probably transported clay from adjacent clay-rich horizons. Whatever the source, it does have a tendency to reduce the porosity-permeability somewhat, but not nearly to the level of the gossan developed from massive sulfide with tuffaceous or chloritic gangue. Where this siliceous gossan is in contact with the glacial material, one might expect this to be receptive to any water which will be coming through the glacial material.

Below the proposed 140 m mine level, the stronger weathering takes the form of a "spike" in cross-sectional view, or a "slot" in three-dimensional view. It commonly penetrates to the 185 m level and locally penetrates below the 230 m level. Margins are generally sharp, going from strongly weathered rock to fresh rock in relatively short distances.

Leaching is the most common destructive agent in the spike. Usually, the spike follows a tuff or chlorite-rich massive sulfide. Usually, there is some evidence of minor shearing, which opened up cracks for the acidic circulating groundwaters to do their destructive work. The acidic solutions not only developed clays, but the clays have commonly gone into solution, resulting in a highly porous and permeable zone. When this zone is tapped by underground workings, large volume water flows may be expected until the storage coefficient has been depleted.

Oxidation (Figure 1D): Oxidation in the massive sulfide is either non-existent or total. Totally oxidized massive sulfide produces a classic "gossan." Gossan is defined as a ferruginous deposit consisting principally of hydrated oxide of iron, and has resulted from oxidation and removal of the sulfur as well as the zinc and copper. The basal contact of the gossan is hairline sharp. Because of lack of drill hole information, the extent of the gossan is unknown. It is known, however, to be present in some places and absent in others.

Hypogene Mineralization (Figure 1E): The reduction in primary sulfides near the surface is due solely to oxidation and leaching. Sphalerite is one of the first minerals to go into solution as a result of leaching by groundwaters. The strongly weathered rocks are nearly totally leached of sphalerite while the lesser weathered rocks show progressively less leaching of sphalerite.

Supergene Mineralization (Figure 1F): The gossan has been enriched in gold and silver. They probably occur dominantly as native elements, having been concentrated as the sulfides oxidize. Beneath the gossan, within the zone of moderate-strong leached sulfides, traces of elemental silver or silver sulfosalts may be present.

In the western half of the deposit, significant chalcocite [Cu_2S] enrichment has occurred in the strongly leached massive sulfide beneath the gossan. Chalcocite occurs primarily as replacement of pyrite grains. These enriched zones are very irregular in shape and distribution and may or may not be of mineable grade.

In the eastern half of the deposit, only traces to local weak zones of chalcocite are present in the leached sulfides beneath the gossan. The main reason is the absence of a near source of copper-rich stringer sulfides, from which copper could be leached and redeposited at depth as chalcocite. Also in the eastern half, local small to modest quantities of secondary zinc minerals such as hemimorphite [$Zn_4(Si_2O_7)(OH)_2 \cdot H_2O$] and smithsonite [$ZnCO_3$] are present. The secondary zinc minerals do not exist in such quantities as to be economic by themselves.

Hanging Wall

The hanging wall rocks react much differently to the weathering processes than either the Crandon Unit or the footwall, primarily for the following two reasons:

1) The rocks are a relatively homogeneous, non-siliceous, fine-grained chloritic tuff.

2) There are only very small amounts (<1 percent) of sulfides present.

Because of pervasive argillization in a cone-shaped zone above the 140 m level (Figure 1C), the rocks are very weak compared to Crandon Unit and footwall rocks. Compressive strengths in weakly argillized rock are generally in the 2,000-5,000 psi range. In the strongly argillized rock, the strengths are considerably less than 2,000 psi. Measurements are difficult in this range, both because it may be hard to find a piece big enough to test, and our equipment is not sensitive in the <1,000 psi range.

It would be difficult and expensive to drive drifts in the moderately argillized hanging wall. If at all feasible, it would be best to get into non-argillized hanging wall, or go into the footwall, where rock strengths at the same mining level may be 5-10 times as strong.

Porosity-Permeability and Argillization (Figures 1B-1C): Because the rock is a non-siliceous chloritic tuff, the primary weathering agent has been pervasive argillization. Since there are no pyrite or base metal sulfides, there is no porosity created by their leaching. The chlorite, sericite and feldspar in the chloritic tuff will alter to various clays in response to chemical weathering. The deepening of the strong and moderate weathering base toward the Crandon formation is a chemical weathering response to the acidic groundwater solutions generated by the leaching of sulfides from the Crandon formation.

The weak porosity-permeability which exists is caused almost entirely by leaching of the fillings of microveinlets. As the microveinlets begin to open up from leaching, they are called fractures. As should be expected, fracture intensity is a function of proximity to the surface. Below the weak weathering zones, fractures average perhaps one per 10-50 feet. In the weak weathering zone, fractures average one per 5-10 feet. In the moderate weathering zone, fractures average one per 1-5 feet. In the strongly weathered zone, fracturing is highly variable, ranging from 10 per foot to one per two feet.

Oxidation (Figure 1D): Oxidation is very extensive in the hanging wall, primarily because there is very little sulfide (<1 percent) to oxidize. The quantity of oxygen in circulating groundwater is sufficient to oxidize isolated grains of pyrite. This is strictly a precise chemical reaction, taking X pounds of oxygen to oxidize X pounds of pyrite. This is dramatically illustrated in figure 1D by the presence of a few local lens of 2-5 percent pyrite which exist in the hanging wall. Even within a totally oxidized environment, the pyrite in these lens is not touched by oxidation. The weakly oxygenated groundwaters were rapidly depleted in oxygen when they attacked the lens of 2-5 percent pyrite, whereas they were able to oxidize the trace amounts of pyrite in the rocks surrounding those lens.

PLANS AND CROSS SECTIONS

Actual plans and cross sections drawn to scale are included as part of this report for several reasons:

1) To discuss the construction and interpretative accuracy of the cross sectional profiles.
2) To illustrate our current level of understanding of the size, shape and distribution of the actual weathering conditions which exist at the Crandon deposit.

3) To discuss some of the known existing conditions which will require more than routine attention during mining.

4) To discuss the nature of the contact between the glacial overburden and the subcrop.

Construction and Interpretation

Cross sectional profiles of weathering are constructed from drill hole data. Generally, from one to three drill holes exist on a cross section between the subcrop and the 230 m level. Because of the paucity of detailed drill data, it is important to consider drill hole information on adjacent cross sections (40 meters away) when drawing the weathering profiles. It is also important to have a good knowledge of the general behavior of the various destructive processes in the particular rock type under consideration. This is why the weathering characteristics and patterns discussed earlier in the generalized cross sections are crucial knowledge to good interpretation. As this knowledge has increased with time, the accuracy of the interpretations on the cross sections has improved. This remains a dynamic rather than a static condition. Interpretations in the future will continue to be a little better than they are today, as our knowledge of weathering characteristics and behavior continues to improve.

Size, Shape and Distribution of Weathering

The shape and distribution of the various weathering conditions can be best understood by viewing both plans and cross sections (Figures 2-10). The plans were constructed from 50 cross sections, by measuring the position of the weathering profile contacts on a particular mining level.

The greatest level of detail we know about weathering at the present time is represented on the cross sections and plans. The confinement of the moderate and strong weathering zones to the Crandon Unit and hanging wall contact is well illustrated in Figures 2 and 3. The trench, a slot-like zone of moderate and strong weathering, has irregular margins and is pod-like in areal distribution. Smooth rolling margins reflect the paucity of detailed drill hole information, which could make some margins quite irregular in shape.

Figures 5 and 6 were constructed in an area of high drill hole density, and therefore, reflect actual conditions and profile shapes with a much higher degree of assurance than other cross sections. The holes were drilled specifically for the purpose of determining detailed weathering characteristics and profile shapes. Five vertical and two angle holes were used in the construction of Figure 5. It is remarkable how consistent the profile is with the hypothetical model of Figure 1A. Four vertical and one angle holes were used in constructing Figure 6. The irregular profile contacts and root-like projections illustrated in this section can certainly be expected to exist on other sections where the current level of information only allows for straight line or smooth projections at this time.

From our current level of understanding, it is unlikely that any major significant weathered zone greater than the drill hole spacing (100-200 feet) has been missed. Small pockets of stronger weathering and irregularities in the currently defined zones do exist, however, but will never be defined until underground development begins. There must be enough flexibility in any predevelopment mining plan to account for such irregularities.

To further illustrate the nature and character of the weathering, several color photographs are included at the back of this report. The majority of the photographs show 30 feet of core per picture, and the general character of a particular weathering zone can be observed. A few close-up shots help illustrate some of the detailed aspects of a particular weathered zone.

Weathering Conditions Related to Mine Planning

Only general conditions will be discussed which pertain to either the footwall or Crandon Unit, and relate to several stopes. Minute details unique to one particular stope will not be discussed.

Footwall: In the footwall, the most obvious problem above the 95 m level is the pervasive moderate leaching. The porous and permeable rocks could act as a channel for the lateral migration of groundwater if a sink is developed. Mining in this environment will be wet, either until the storage capacity is depleted or until recharge is reduced or cut off.

Crandon Unit: Perhaps the area of most concern is the hanging wall contact of the ore zone. It is along this contact that often the strongest weathering is concentrated, and the most strongly bedded and foliated rocks exist (Figures 2-10). Such a condition creates potential for excessive dilution, if left unchecked during mining. Such an environment is not pervasive, however, and local conditions must be evaluated on a stope by stope basis.

A second area of concern is a deep, root-like projection of moderate and strong weathering which penetrates below the 230 mining level between east-west coordinates 94 320 and 94 520. This zone is of concern because it is within several of the initial mining stopes. Special attention must be given to any potential dilution and water inflow which may exist. Figure 3 best illustrates this zone, as well as two others in the western half of the Crandon Unit at approximately 93 760 and 93 600. Volumetrically, these zones represent less than 5 percent of the ore beneath the 230 level.

A third area of concern is the moderate to strong leaching of much of the weathered rock. Until the storage capacity of the porous area is drained, working conditions will be wet during development of the porous areas. Weak compressive strengths are also associated with the more heavily leached zones. This type of environment is confined primarily within the moderate and strong weathering outlined in Figures 2 and 3.

Hanging Wall: The most obvious problem in the hanging wall is low compressive strengths associated with moderately and strongly weathered, pervasively argillized rock (Figures 1A, B). As a general rule, compressive strengths above the 95 m level would need continuous support, as well as some areas between the 95 m and 140 m levels. As more point load data are acquired, there will be more areas within which reasonably accurate compressive strengths may be determined.

Subcrop Contact Zone

The immediate contact of the subcrop with the glacial debris is of importance because it is more resistive to the flow of water than either the glacial debris above, or the weathered rock below. This is true because chemical weathering at the contact is strongest, and there is generally an abundance of iron-magnesium and feldspathic silicates from which clays have developed.

Details of the character of the upper weathered zones have been discussed under the generalized illustrative cross section portion of this report. To summarize:

Footwall:

Has a tendency to be a little leaky because the rock is siliceous, moderately leached, with only modest clay development. In the eastern one-half of the area, it is not siliceous and weathers to an impermeable clay-rich cap.

Crandon Unit (west half):

Massive sulfide with chloritic gangue and interbedded tuffs result in a very impermeable clay-rich weathered cap.

Crandon Unit (east half):

Sixty percent siliceous massive sulfide which weathers to a porous cellular boxwork gossan with minor clay. Forty percent chloritic massive sulfide, tuffs and argillite, which weathers to an impermeable clay-rich cap.

Hanging Wall:

Weathers to a strong pervasive clay to considerable depths. Permeability is very low.

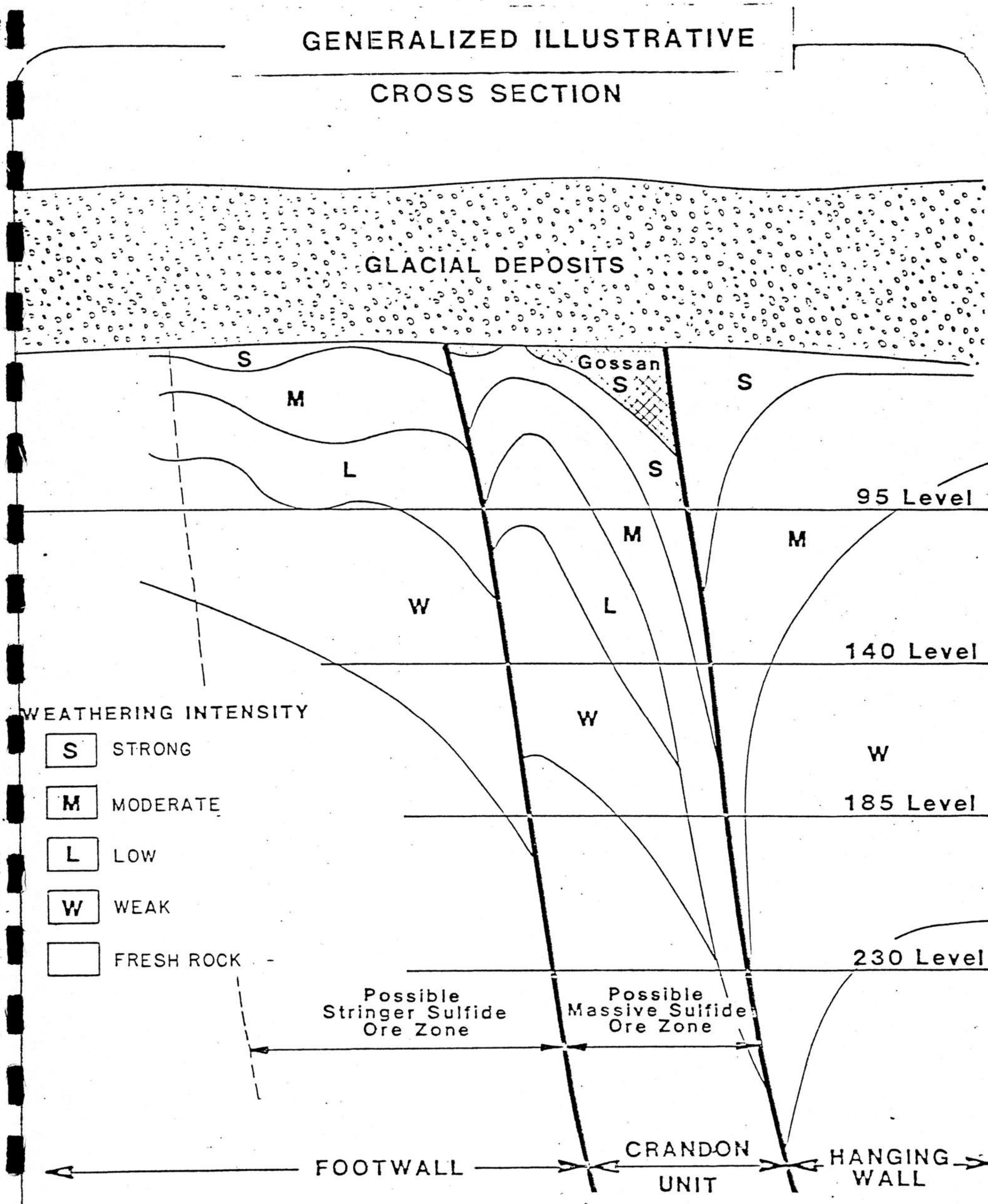
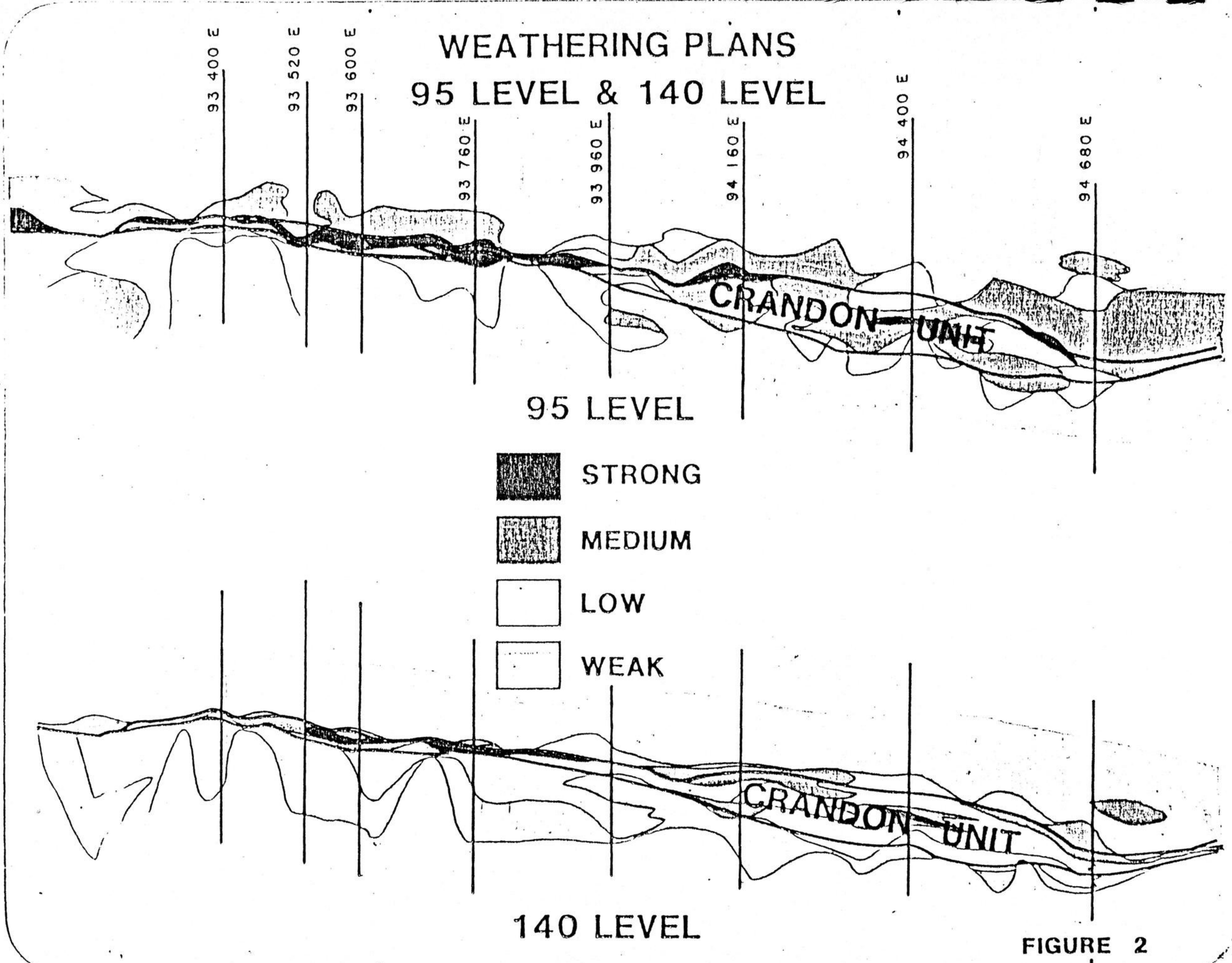
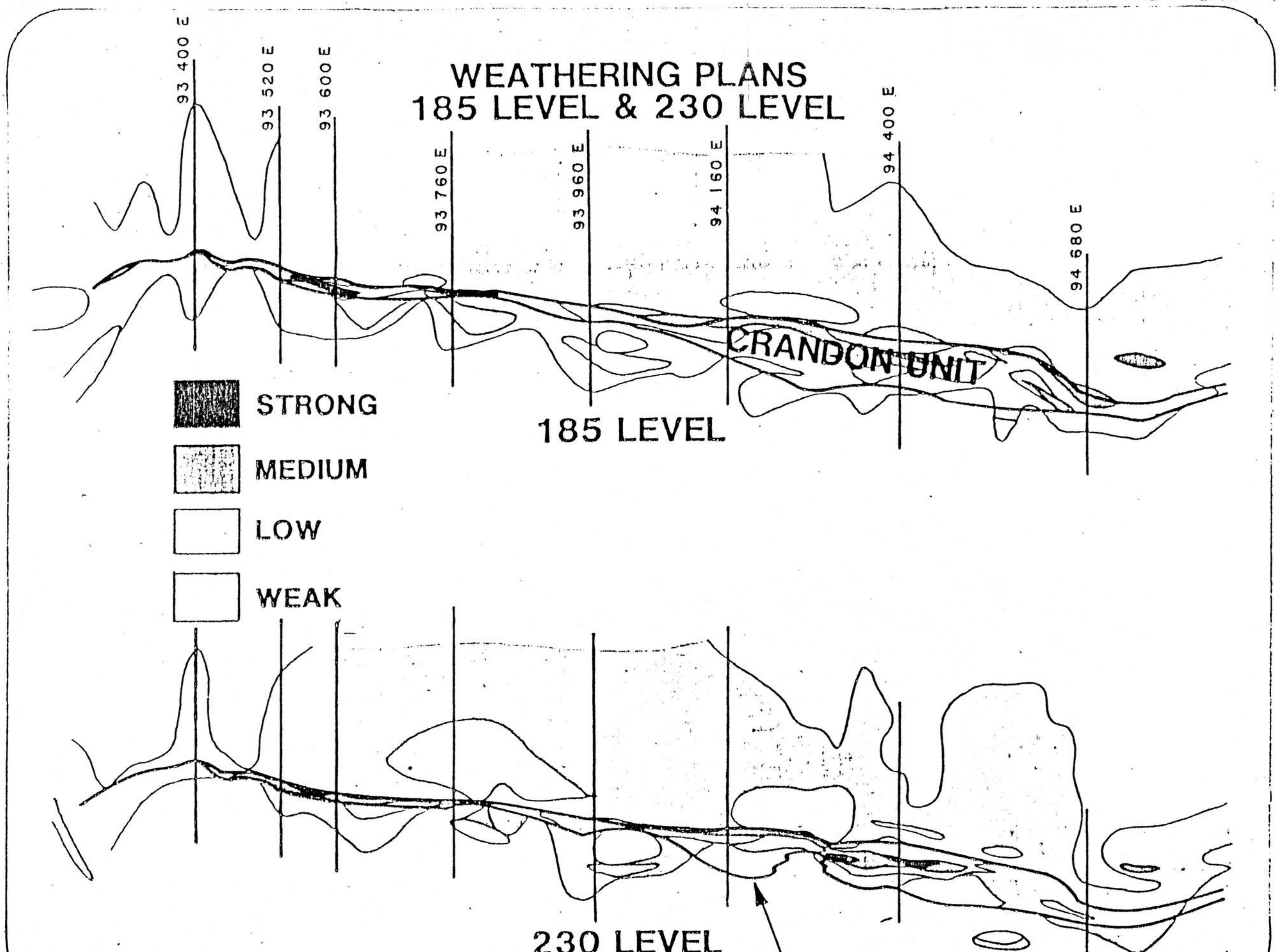

GENERALIZED ILLUSTRATIVE
CROSS SECTION
GLACIAL DEPOSITS
Gossan
S
M
L
W
95 Level
140 Level
185 Level
230 Level
WEATHERING INTENSITY
S STRONG
M MODERATE
L LOW
W WEAK
FRESH ROCK
Possible Stringer Sulfide Ore Zone
Possible Massive Sulfide Ore Zone
FOOTWALL
CRANDON UNIT
HANGING WALL

FIGURE 1 A



WEATHERING PLANS
95 LEVEL & 140 LEVEL
93 400 E
93 520 E
93 600 E
93 760 E
93 960 E
94 160 E
94 400 E
94 680 E
CRANDON UNIT
95 LEVEL
STRONG
MEDIUM
LOW
WEAK
CRANDON UNIT
140 LEVEL

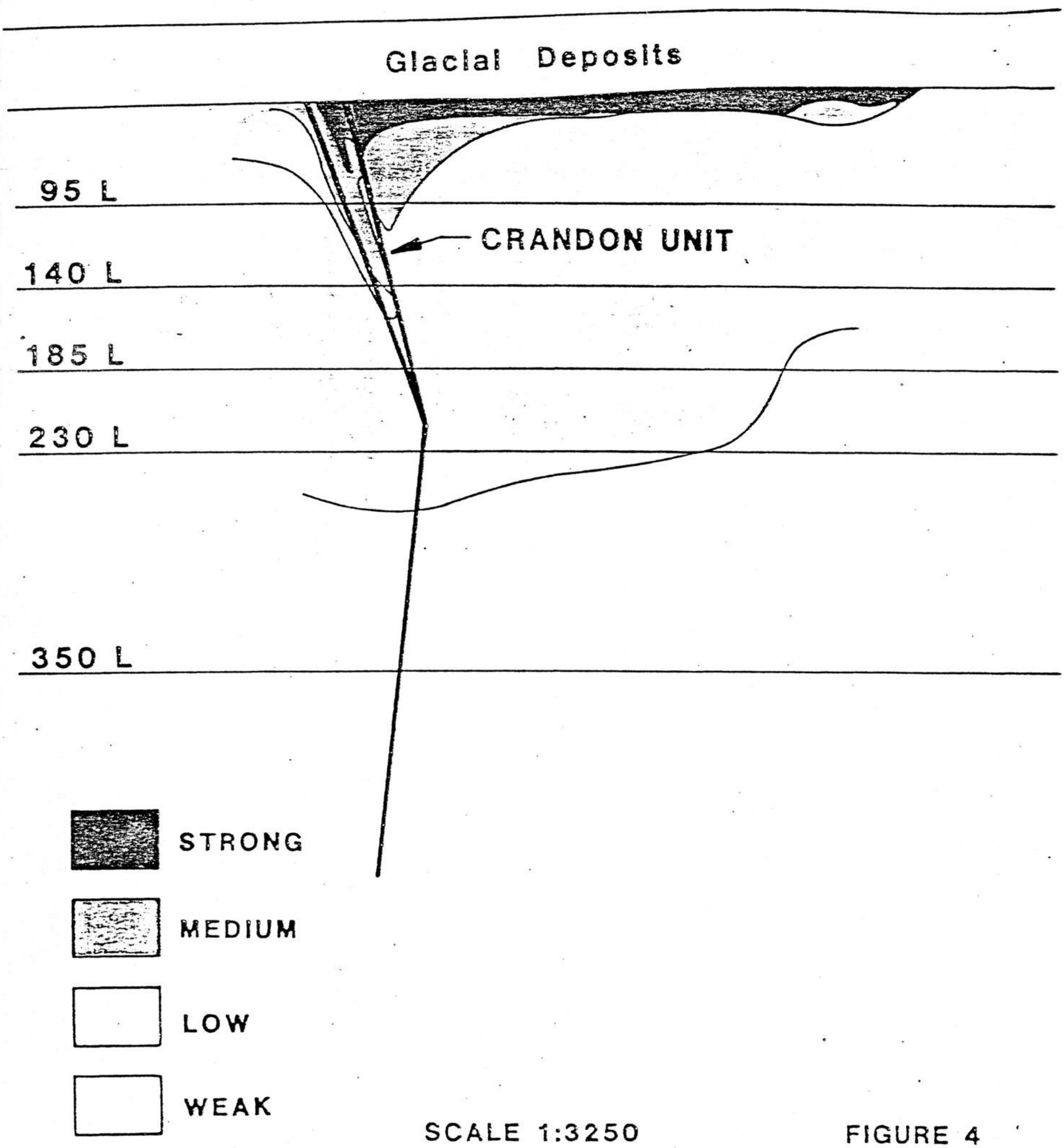
FIGURE 2



WEATHERING PLANS
185 LEVEL & 230 LEVEL
93 400 E
93 520 E
93 600 E
93 760 E
93 960 E
94 160 E
94 400 E
94 680 E
CRANDON UNIT
STRONG
MEDIUM
LOW
WEAK
185 LEVEL
230 LEVEL
CRANDON UNIT

FIGURE 3

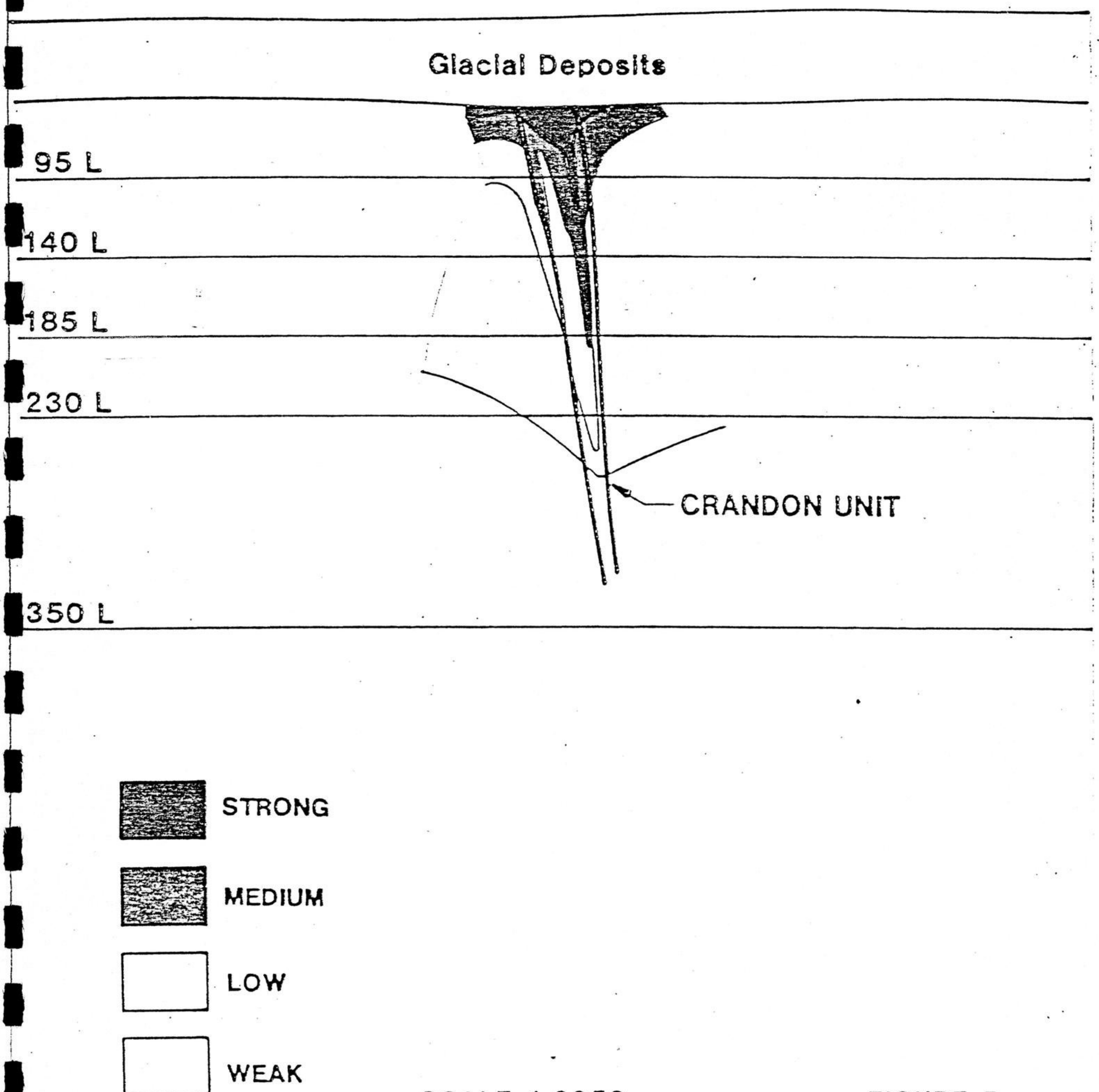
93 400 E CROSS SECTION
WEATHERING ZONES



SCALE 1:3250

FIGURE 4

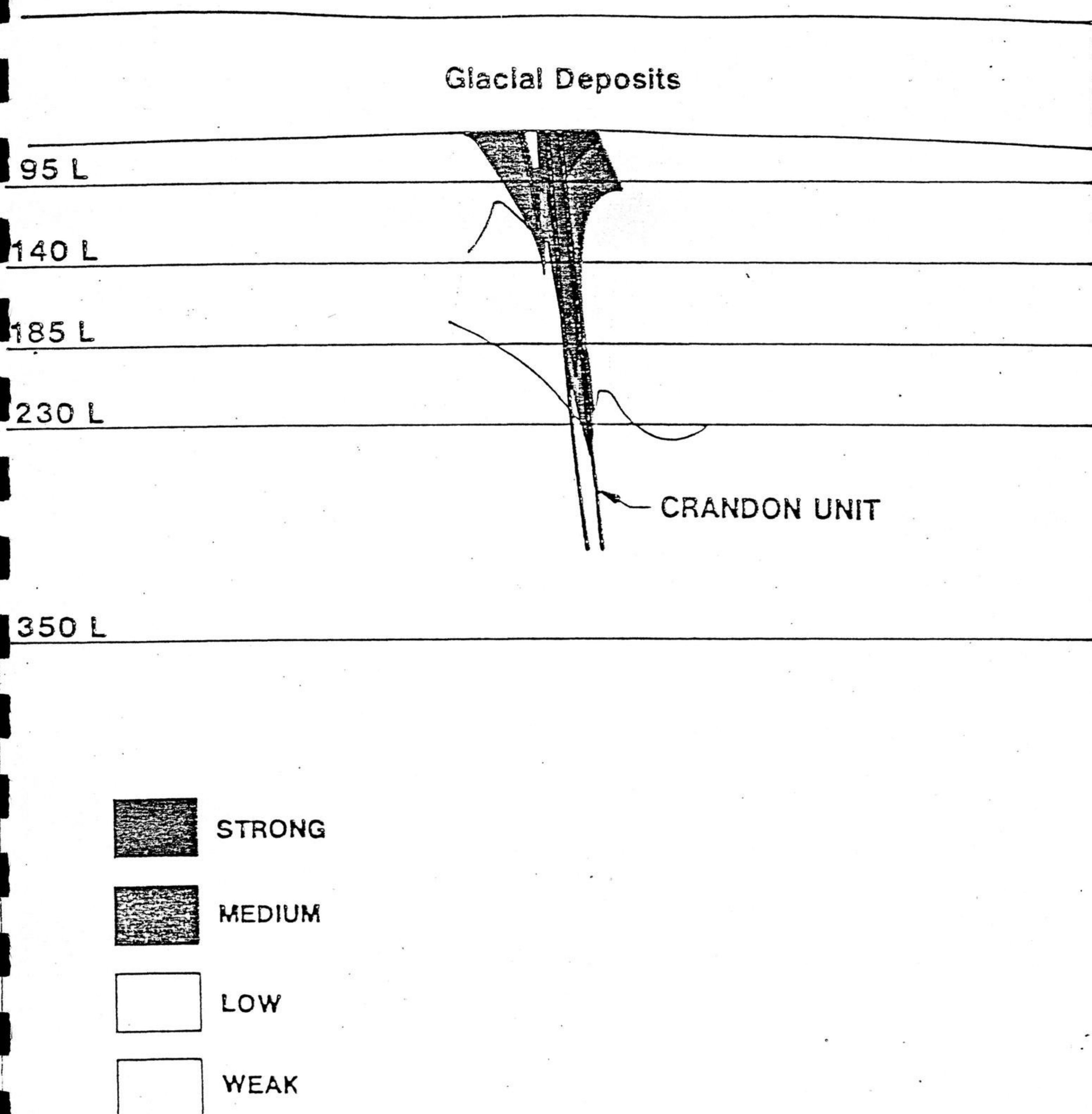
93 520 E CROSS SECTION
WEATHERING ZONES



SCALE 1:3250

FIGURE 5

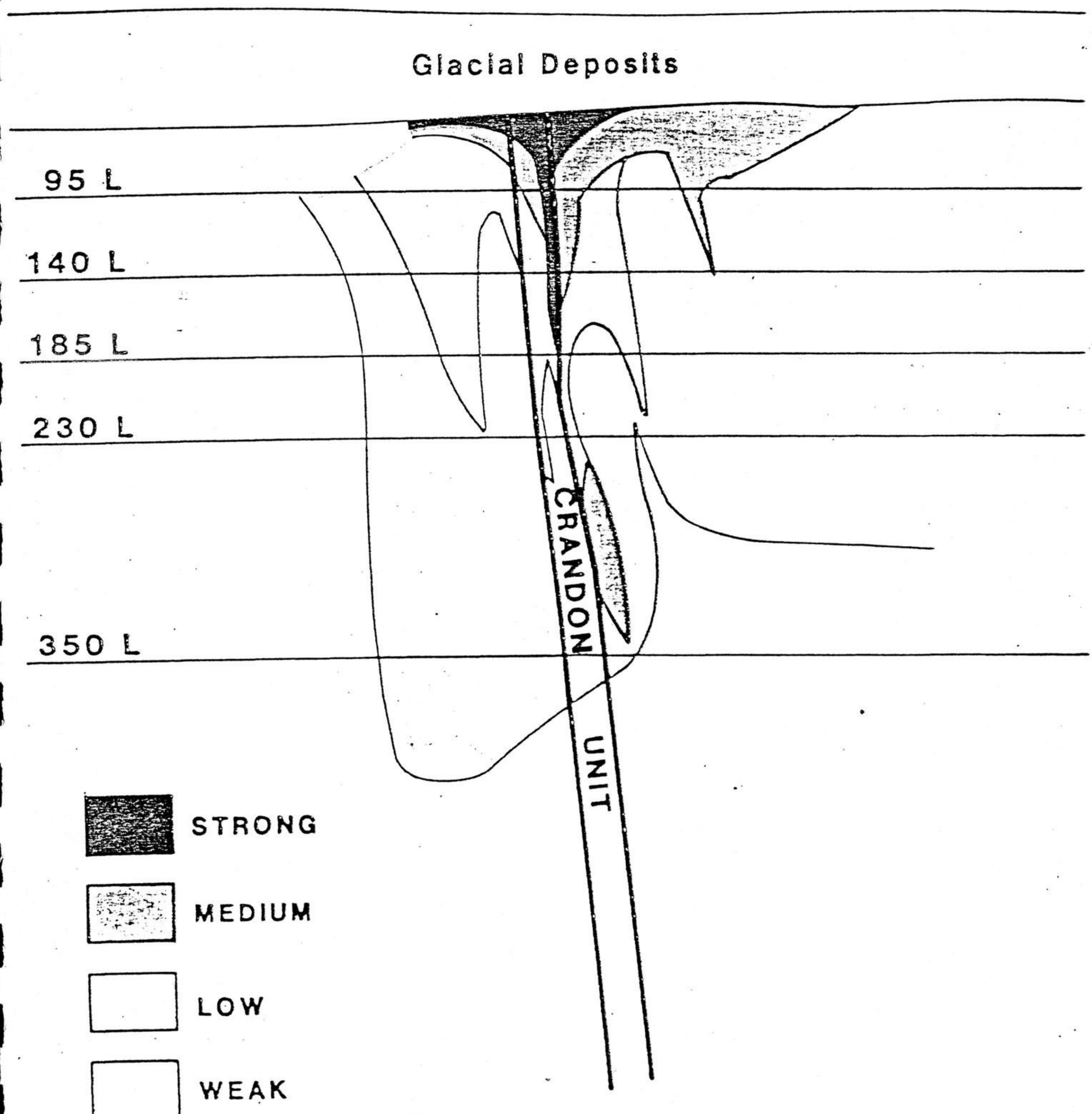
93 760 E CROSS SECTION
WEATHERING ZONES



SCALE 1:3250

FIGURE 6

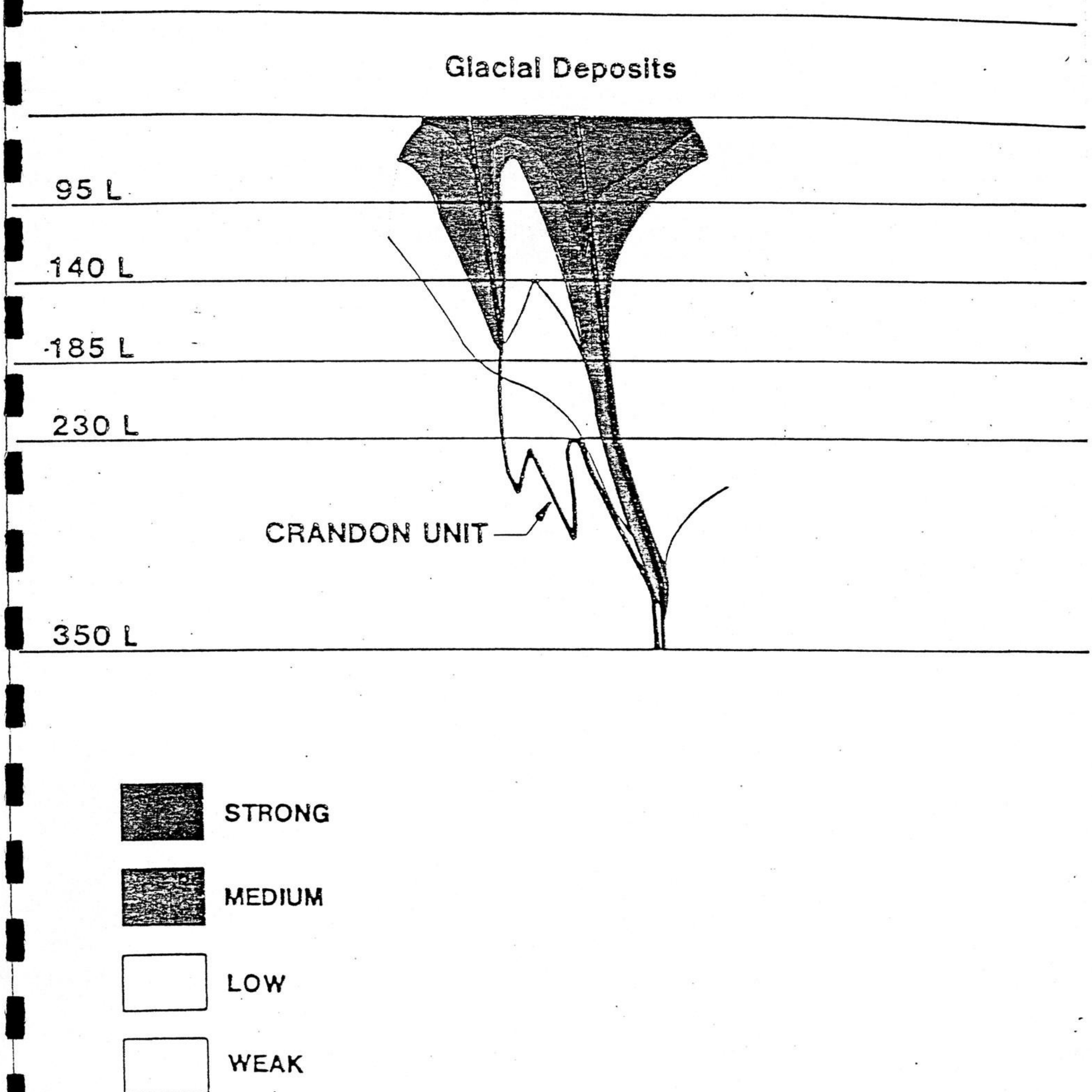
93 960 E CROSS SECTION
WEATHERING ZONES



SCALE 1:3250

FIGURE 7

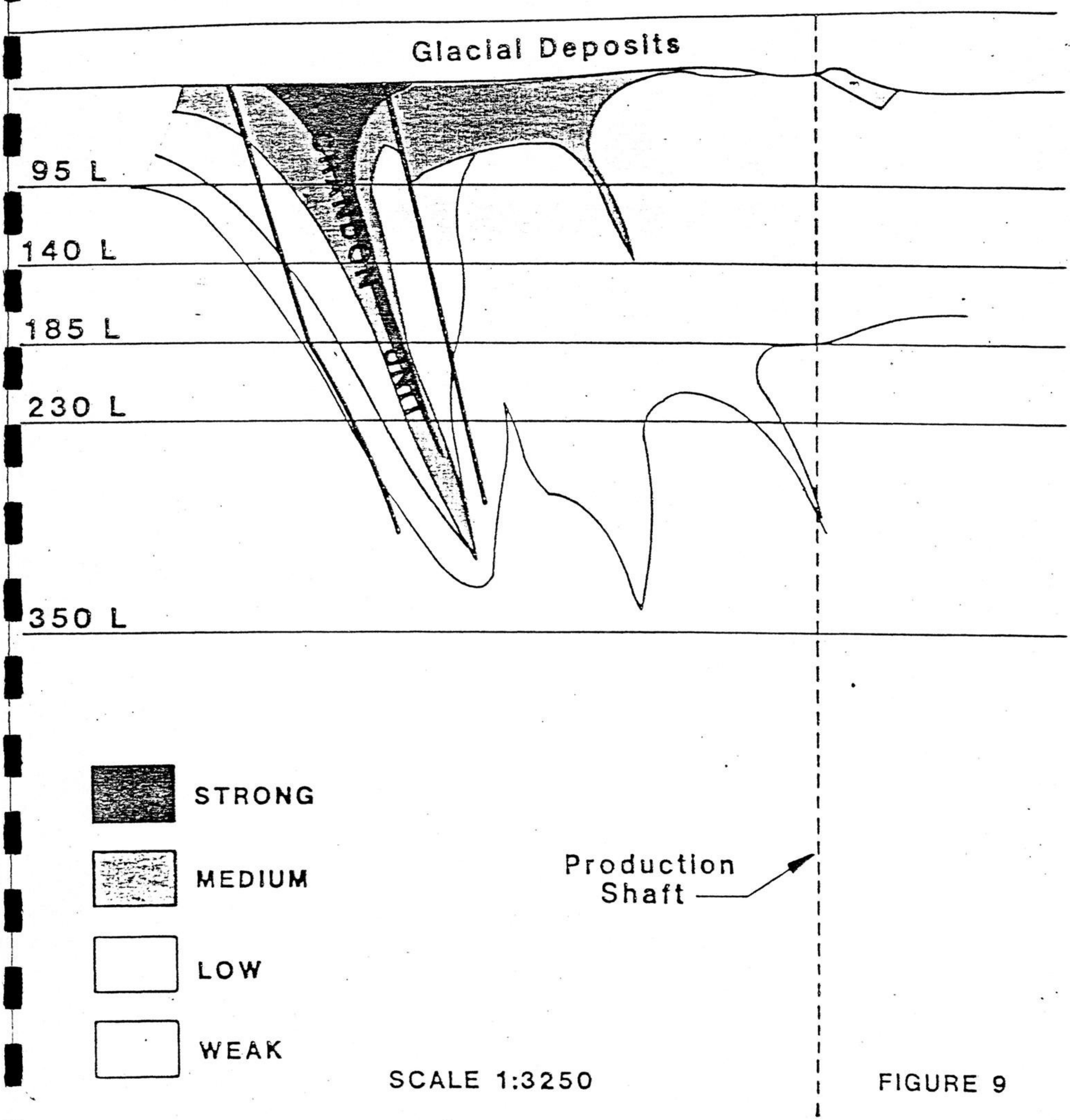
94 160 E CROSS SECTION
WEATHERING ZONES



SCALE 1:3250

FIGURE 8

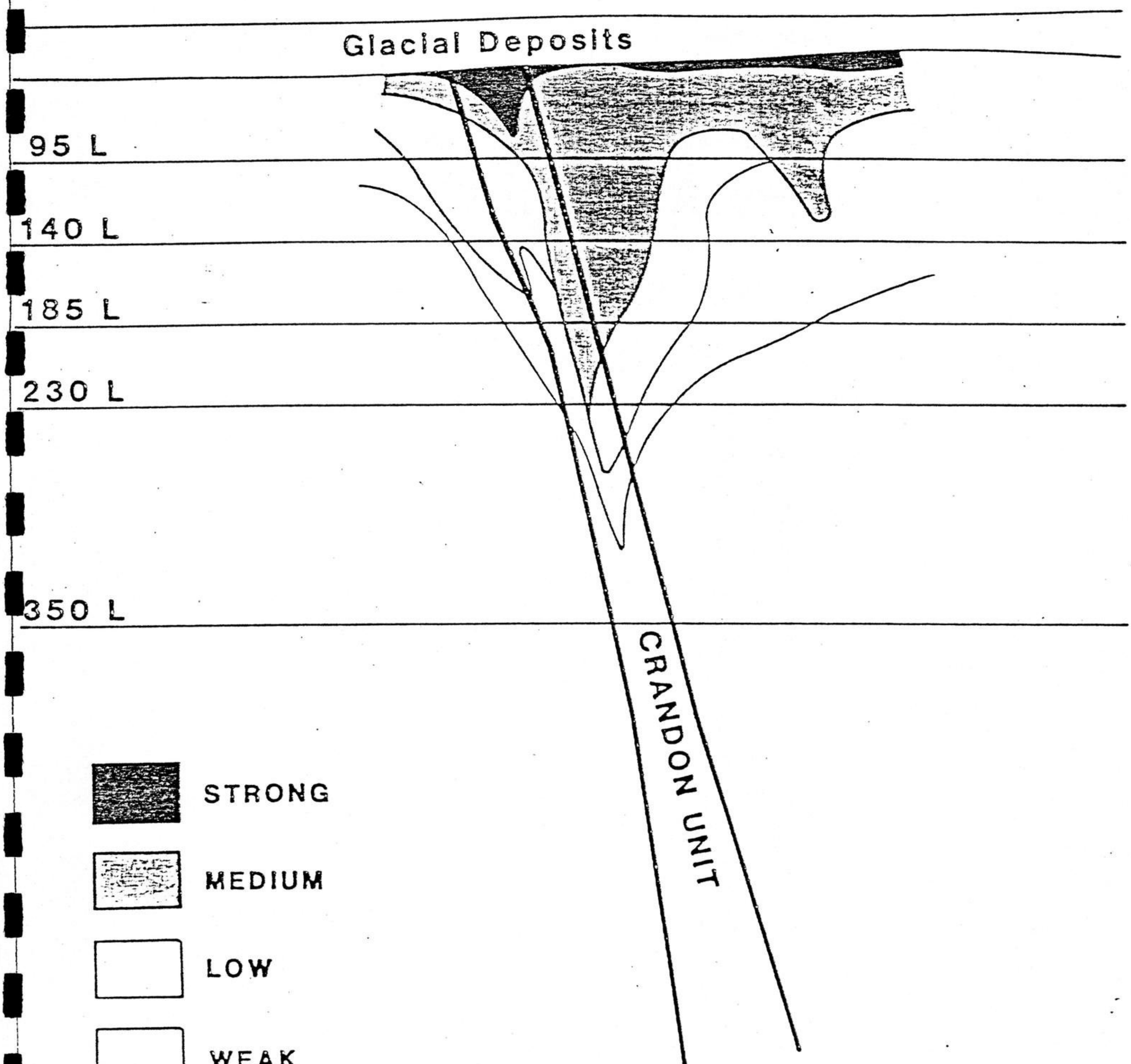
94 400 E CROSS SECTION
WEATHERING ZONES



SCALE 1:3250

FIGURE 9

94 680 E CROSS SECTION
WEATHERING ZONES



SCALE 1:3250

FIGURE 10

GENERALIZED ILLUSTRATIVE
CROSS SECTION
POROSITY - PERMEABILITY

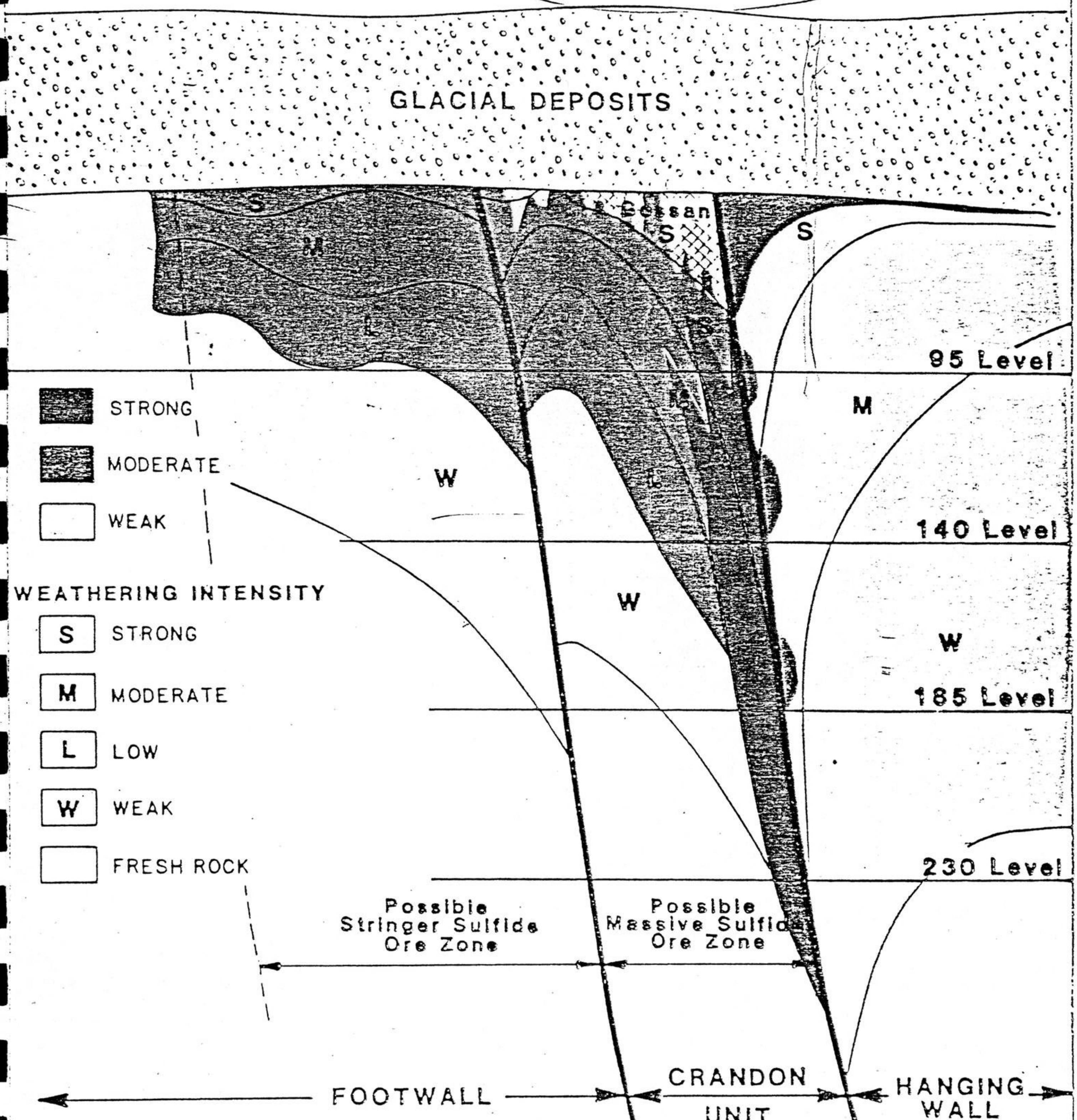


FIGURE 1 B

GENERALIZED ILLUSTRATIVE CROSS SECTION

ARGILLIZATION

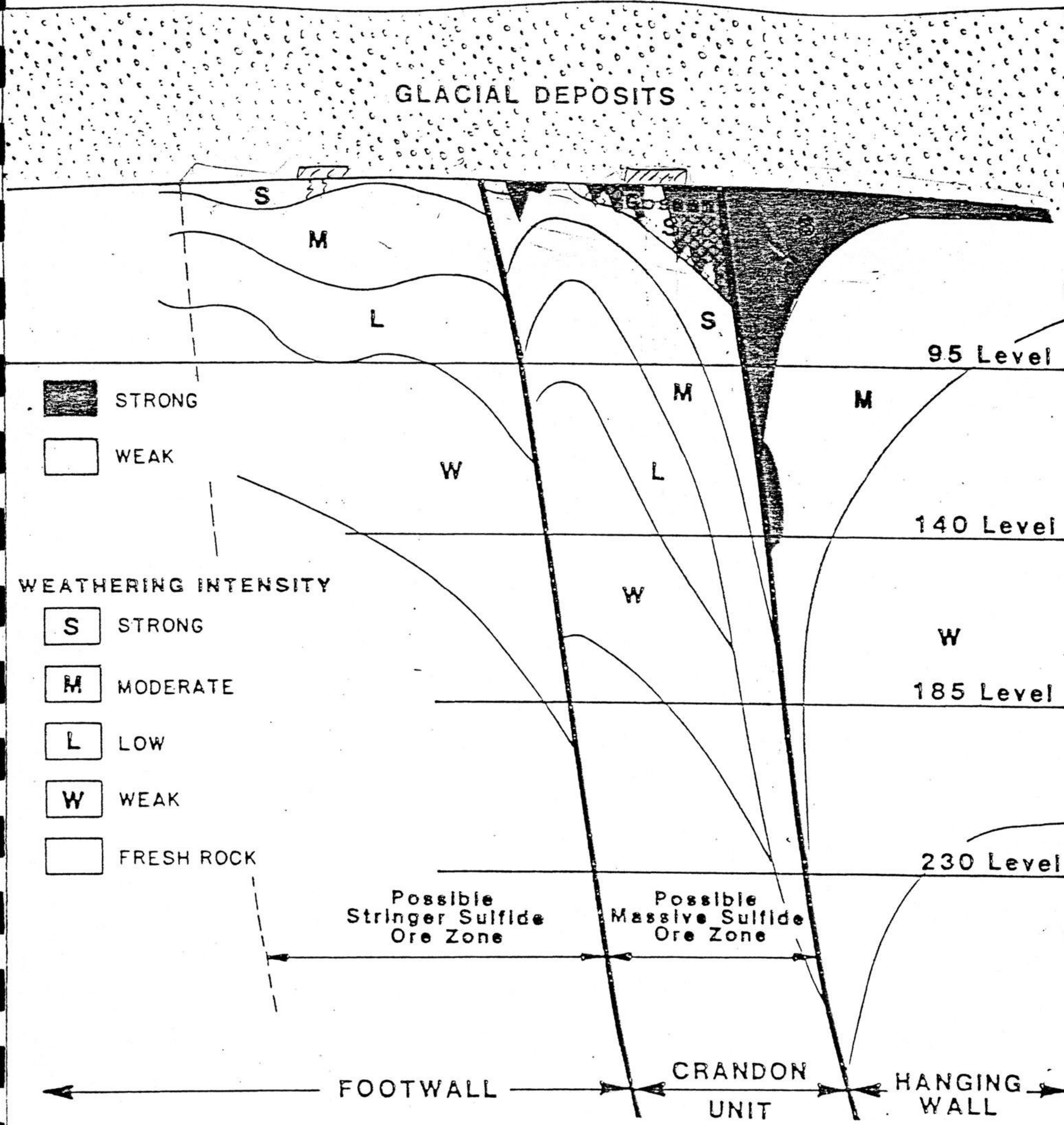
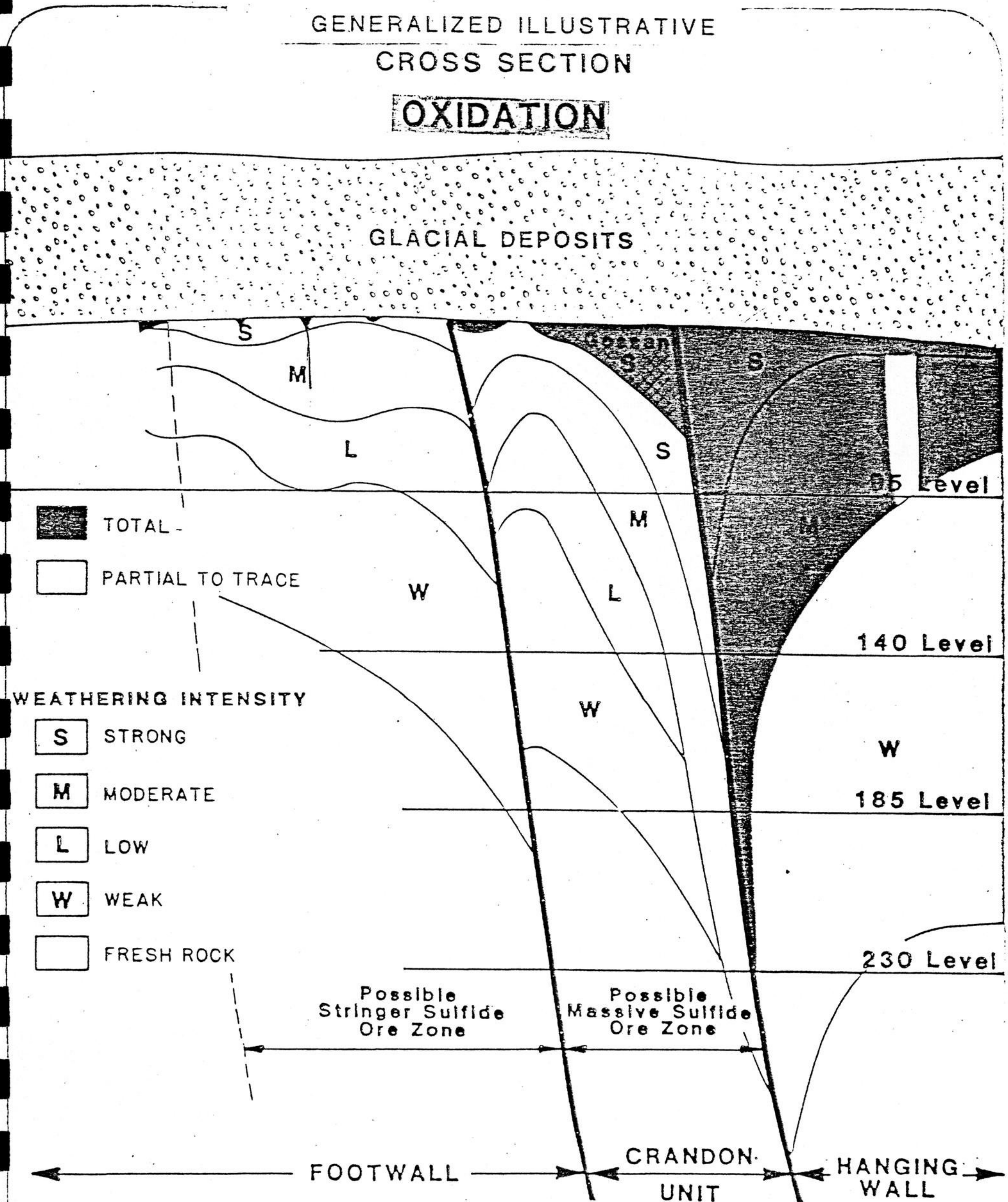


FIGURE 1 C



GENERALIZED ILLUSTRATIVE
CROSS SECTION
OXIDATION
GLACIAL DEPOSITS
Gossan
S
M
L
W
95 Level
140 Level
185 Level
230 Level
TOTAL
PARTIAL TO TRACE
WEATHERING INTENSITY
S STRONG
M MODERATE
L LOW
W WEAK
FRESH ROCK
Possible Stringer Sulfide Ore Zone
Possible Massive Sulfide Ore Zone
FOOTWALL
CRANDON UNIT
HANGING WALL

FIGURE 1 D

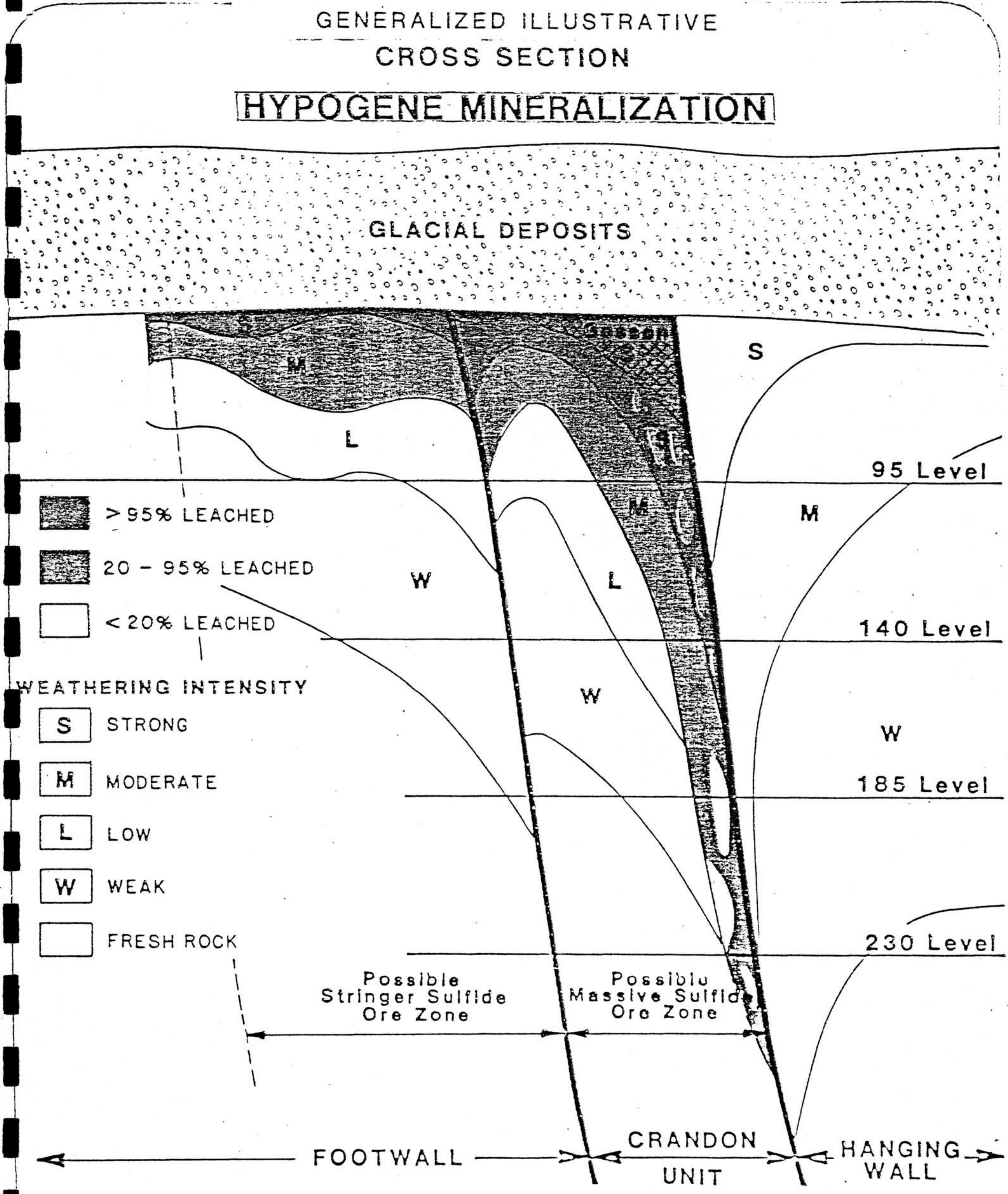

GENERALIZED ILLUSTRATIVE
CROSS SECTION
HYPOGENE MINERALIZATION
GLACIAL DEPOSITS
Gossan
S
M
L
W
95 Level
140 Level
185 Level
230 Level
> 95% LEACHED
20 - 95% LEACHED
< 20% LEACHED
WEATHERING INTENSITY
S STRONG
M MODERATE
L LOW
W WEAK
FRESH ROCK
Possible Stringer Sulfide Ore Zone
Possible Massive Sulfide Ore Zone
FOOTWALL
CRANDON UNIT
HANGING WALL

FIGURE 1 E

GENERALIZED ILLUSTRATIVE CROSS SECTION

SUPERGENE MINERALIZATION

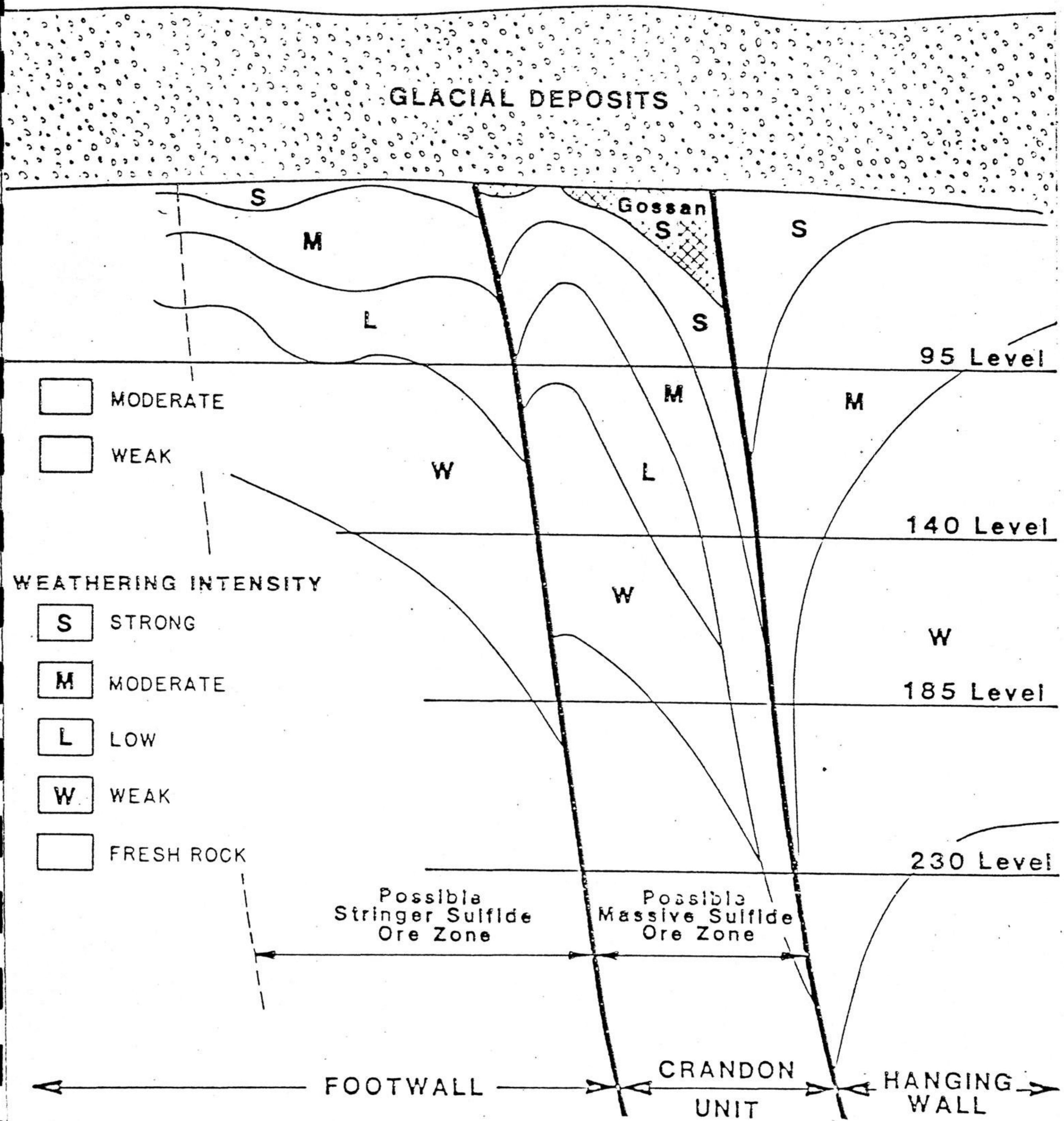


FIGURE 1 F

PLATE 1 Drill Hole #176

1055 - 1071
MODERATE WEATHERING
Crandon Formation Tuff and Massive Sulfide
Moderate Leaching
Weak Argillization
Weak Fracturing

PLATE 2 Drill Hole #175

643 - 653
STRONG WEATHERING
Crandon Formation Massive Sulfide
Strong Leaching
Strong Fracturing

653 - 680
STRONG WEATHERING
Crandon Formation Massive Sulfide
Total Oxidation (Gossan)
Strong Leaching
Strong Fracturing

PLATE 3 Drill Hole #178

488 - 496
MODERATE WEATHERING
Hanging Wall Tuff
Total Oxidation
Weak Leaching
Weak Argillization
Weak Fracturing

496 - 532
STRONG WEATHERING
Crandon Formation Massive Sulfide
Total Oxidation (Gossan)
Strong Leaching
Moderate Fracturing

532 - 545
MODERATE WEATHERING
Crandon Formation Massive Sulfide
Moderate Leaching
Weak Argillization

PLATE 4 Drill Hole #178

(Close-up of Righthand Box in Plate 3)

498 - 496
MODERATE WEATHERING
Hanging Wall Tuff
Total Oxidation
Weak Leaching
Weak Argillization
Weak Fracturing

PLATE 5 Drill Hole #176

1102 - 1144
STRONG WEATHERING
Crandon Formation Pyrite Tuff
Strong Leaching
Strong Argillization
Moderate Fracturing

PLATE 6 Drill Hole #175

612 - 643
MODERATE WEATHERING
Crandon Formation Massive Sulfide
Strong Leaching
Moderate Fracturing

643 - 650
STRONG WEATHERING
Crandon Formation Massive Sulfide
Strong Leaching
Strong Fracturing

PLATE 7 Drill Hole #96

960 - 967
STRONG WEATHERING
Crandon Formation Massive Sulfide
Strong Leaching
Strong Argillization
Moderate Fracturing

967 - 971
WEAK WEATHERING
Crandon Formation Massive Sulfide
Weak Leaching

PLATE 8 Drill Hole #96

(Close-up of Plate 7)

960 - 967
STRONG WEATHERING
Crandon Formation Massive Sulfide
Strong Leaching
Strong Argillization
Moderate Fracturing

PLATE 17 Drill Hole #237

1037 - 1044
LOW WEATHERING
Hanging Wall Tuff
Moderate Leaching

PLATE 18 Drill Hole #237

(Close-up of Plate 17)

1037 - 1044
LOW WEATHERING
Hanging Wall Tuff
Moderate Leaching

PLATE 19 Drill Hole #237

1006 - 1011
WEAK WEATHERING
Hanging Wall Tuff
Weak Leaching

1011 - 1016
LOW WEATHERING
Hanging Wall Tuff
Moderate Leaching
Trace Oxidation

PLATE 20 Drill Hole #240

628 - 655
WEAK WEATHERING
Hanging Wall Tuff
Weak Leaching
Trace Oxidation

PLATE 21 Drill Hole #176

1020 - 1051
WEAK WEATHERING
Crandon Formation Pyrite Tuff
Weak Leaching
Partial Oxidation

PLATE 22 Drill Hole #74

589 - 598
WEAK WEATHERING
Hanging Wall Tuff
Weak Leaching
Trace Oxidation