National Exams May 2010

98-MMP-A2 Mining Methods and Design

3 hours duration

NOTES:

1. If doubt exists as to the interpretation of any question, the candidate is urged to submit with the answer paper, a clear statement of any assumptions made.

2. This is an *OPEN BOOK EXAM*.
   Any non-communicating calculator is permitted.

3. ***FIVE*** **(5)** questions constitute a complete exam paper.

5 Only the **first five** questions will be marked in the order they appear in the answer book. Each of these five questions is of equal value (20 marks).

6 Five questions in total must be answered.

7 Some questions require an answer in essay format. Clarity and organization of the answer are important. Some questions require **neat** sketches as part of, or to illustrate your answers. Only neat legible sketches will be qualify for full marks.

8 Be aware of the marks allocated to each part of any question, and spend the appropriate amount of time on your answer, not more, not less.

Question 1 Open Pit Oil Coal Mining

A coal deposit in the rocky mountain region of western Canada is at the feasibility stage. The coal seams are near vertical and the strike length of the deposit is of the order of 5 kilometers. The deposit is displaced 10's of meters by very widely spaced near vertical to sub-vertical faults striking approximately across the strike of the coal seams. The seams have some differences in composition and in some cases will be sold as single high revenue products and in other cases blended. A sketch section is shown in Figure 1, indicating the probable outline of the pit which will be about 4 kilometers long on strike.

1.1) What equipment would be used for stripping, develop a stripping schedule, and where would the waste be deposited to minimize the environmental footprint. Sketch a schematic of the operation at a point in time where half the coal on a particular section has been extracted.

1.2) Waste stripping could be moved using at least three distinctly different methods. Describe such methods, and indicate the approximate unit cost for each. Justify your choice of method.

1.3) What types of equipment would be used for coal mining and inter-seam stripping. Sketch a section showing how and where, in relation to the coal seams, such equipment would operate, again at a point in time where half the coal on a your section has been extracted.

1.4) How would the coal and inter coal waste be transported. Indicate how you will satisfy the constraint of separating high revenue from blended seams.

(5 marks for each of 1.1 to 1.4 above, total 20)

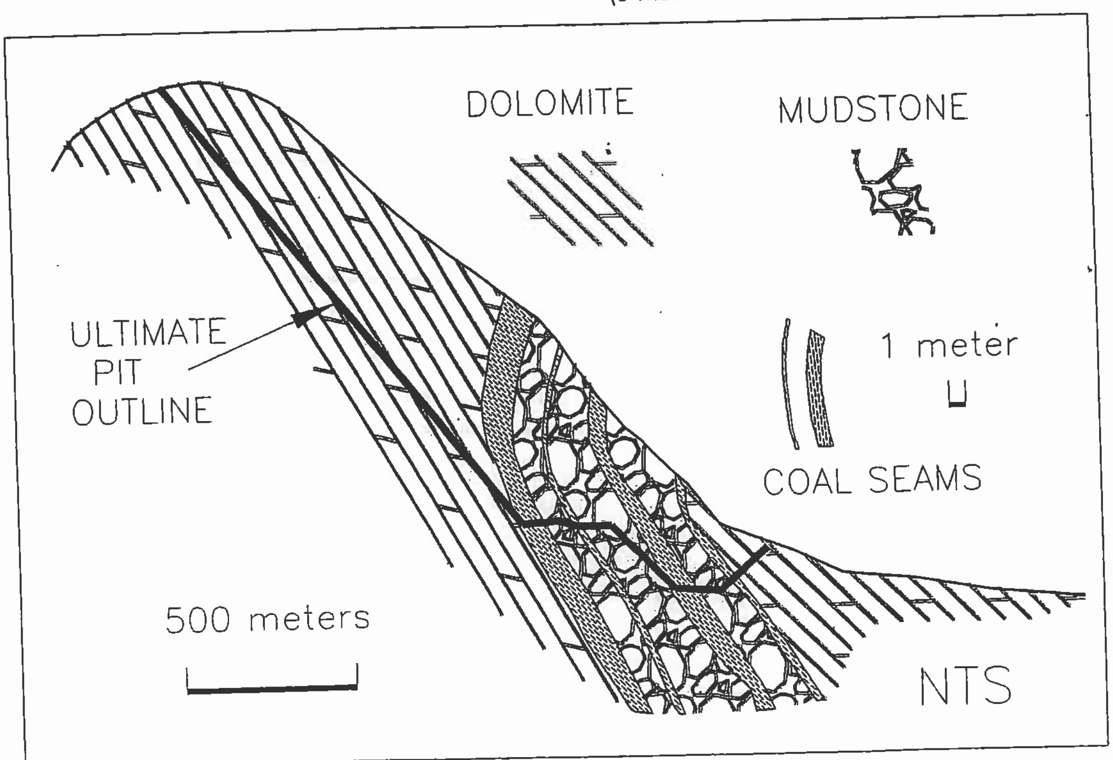

Figure 1. Section across strike showing original topography and eventual open pit (dotted). Also shown are the coal seams and inter-seam waste but not to scale. The coal seams are thinner than they appear and have an auxiliary scale bar of 10 meters. The main figure has a 500 meter scale bar.

Question 2 Open Pit Optimization

Describe the Lerchs-Grossman open pit limit optimization procedure, and discuss how the time value of money might be included in the optimization. How would you decide on the penultimate and ultimate pit expansions given a large 3 kilometer diameter approximately circular open pit.

(6 marks)

Figure 2 shows a simple 2 dimensional section of an open pit being mined with 15 x 15 meter square blocks and a 45 degree wall slope. The cash flow per block is indicated and waste blocks are shown negative. The example is "contrived" to demonstrate the problem.

How is the cash flow of (2.1) negative waste blocks and (2.2) positive (ore) blocks calculated.

(4 marks)

On the section Figure 2 (page 4) indicate the L-G optimal pit outline. (2.3) how many ore blocks and (2.4) how many waste blocks are mined and (2.5) what is the total "cash flow".

Space has been allocated on the figure for calculations and Figure 2.a (page 5) is a duplicate in case you need to revise your answer. You may use the "floating/moving cone" method if you wish, but you will loose 1/2 your marks in this part of the exam for doing so (maximum 5 marks not 10). You must detach the figures and place them in your exam answer book with your name printed in the space provided on all the figures.

(10 marks)

Your Name ______________________

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Figure 2. Top part shows the cash flow for each block on a single two dimensional section for a typical pit expansion. The middle and lower parts of the figure are spaces to calculate the Lerchs-Grossman "optimal" pit expansion. Blocks are 15x15m and wall slope 45 degrees.

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Figure 2.a. Copy of Figure 2 in case you make your answer neater or re-calculate. Top part shows the cash flow for each block on a single two dimensional section for a typical pit expansion. The middle and lower parts of the figure are spaces to calculate the Lerchs-Grossman "optimal" pit expansion. Blocks are 15x15m and wall slope 45 degrees.

Question 3 Open Pit In-Pit Crushing and Conveying

With increasing diesel fuel costs and reduced reliability of supply in some countries, and the availability of cheaper reliable electrical power, many mines are looking seriously at alternatives to truck haulage as open pit mines become deeper.

Describe, compare and contrast the planning for, and installation of, an in-pit crushing and conveying system at the following points in the life of a mine. Discuss advantages and disadvantages, and broadly compare unit and capital costs of trucking versus in-pit crushing/conveying.

3.1) At the feasibility and mine design stage. (6 marks)

3.2) Half way through the life of an open pit employing push-backs all round at various times. (6 marks)

3.3) Make a detailed sketch indicating the overall layout of the crushing infrastructure, truck dump area and conveyor way up the pit wall. Indicate the major components of the system. (8 marks)

Question 4 Progression from Open Pit to Underground Mining by Sub Level Caving

A profitable open pit mine is about a quarter of the way through its ultimate life. It has been suggested that underground mining could not only extend the mine life beyond the end of open pit mining, but might be a more profitable alternative now.

4.1) Describe how you would calculate the "break-even" point where a smaller pit would be completed early and underground mining commence as the main ore supplier. Discuss the advantages and disadvantages of proceeding to underground mining at an apparently earlier stage than would be indicated from open pit economics alone. (6 marks)

In this case, sub-level caving is indicated as the preferred underground mining method.

4.2) Discuss the "geology" in terms of relative dimensions and dip of ore, the quality of the rock mass of the hanging and foot walls, and the ore. (4 marks)

4.3) Describe the sub-level caving method and the sequence of mining (4 marks)

4.4) What steps must be taken to maximize recovery and minimize dilution and how has the design of the caving stopes in modern mines been modified to achieve these objectives. (6 marks)

Question 5 Underground hoist systems

5.1) Name three types of mine hoisting ropes in general use in underground mines. Describe each type, and in what context and hoisting method each would be preferred.

(6 marks)

5.2) Hoist, sheave and head-frame design are inter-related. Discuss the following in this context;

5.2.a) What is the critical design parameter of a head-frame.

5.2.b) What is the fleet angle.

5.2.c) What is the basis for selection of the diameter of the sheave wheel.

5.2.d) What determines the rope diameter.

(3.5 marks each)

Question 6 Cut and Fill Mining

An ore zone in an underground mine is being considered for production. The zone comprises a narrow vein of average width of 1 meter and is very rich. The mining method being considered is "ramp-in-vein" cut and fill. In order to improve the extraction and recovery, resuing will be used to limit ore vein dilution.

6.1) With the aid of sketches, describe the general mining sequence of ramp-in-vein cut and fill mining.

(7 marks)

6.2) In the context of underground mining what is "resuing" . Again, provide suitable sketches and describe how the economics of the ore zone here will be improved with the use of this technique.

(6 marks)

6.3) When using the "ramp-in-vein" cut and fill method coupled with resuing, what types of drilling, loading and haulage equipment would be used in typical stopes and describe how the equipment is positioned with respect to the vein.

(7 marks)

Question 7 Underground Mine Design

This question refers to Figures 7.1 and 7.2 on pages 9 and10. In case you need a spare copy to make a neater drawing, or to change your drawing, duplicate copies of the figures are also attached as Figures 7.1.a and 7.2.a on pages 11 and 12.

You must detach the figures and place them in your exam answer book with your name printed in the space provided on all the figures. The completed figures comprise a large proportion of the marks for this question, so do not forget to place them in your answer book.

Your geology department has found a new sector in the mine. An exploration drift of dimensions 4 meters wide by 4 meters high (shown on the drawings, Figures 7.1 and 7.2) has been driven. From there, diamond drilling has defined the shape and extent of ore in this sector.

The geological interpretation is provided in cross section (Figure 7.1) and in plan view (Figure 7.2). The zone of interest is 20 meters high by 30 meters long. The dip of the ore varies between 50 and 90 degrees. Its horizontal thickness varies between 3 and 8 meters.

There is a fault on the hanging wall of the ore with horizontal thickness between 1 and 3 meters.

A smaller cleaner fault cuts through the zone and displaces the top part of the mineralization downwards towards the south.

The rock mass quality of the various units is the following:

- Footwall rock: Very good quality rock mass, minimum ground support required.
- Ore: Good quality rock mass, does not present problems if local ground support is installed.
- Fault material: Bad quality rock mass. It is expected that half the fault will fall into the stope even if ground support is installed. Even more ground falls can be expected if no local ground support is installed.
- Hanging wall: Good quality rock mass.

The grade of the ore is very high. It is sufficiently rich to support the cost of virtually any mining method. There are no other developments in the area. The ore and waste will need to be hauled to a nearby ore-pass and waste pass. Auxiliary ventilation can be supplied without problem.

Your objective is to mine out this zone within the limits stated above. Answer the following questions.

7.a) What mining method would you apply in this case and explain your choice of method.

(6 marks)

7.b) Explain in your own terms how you would mine this zone and in what mining sequence, including development outside the stope and the actual mining. You can assume that you have access to any equipment that you want that is cost effective and suitable for the purpose.

7.c and 7.d) Use the two Figures 7.1 and 7.2 to sketch a typical access in waste and the ore development. Make the sketches simple, a whole stope layout is not required, just a simple illustration on Figures 7.1 (Question 7.c) and 7.2 (Question 7.d) of your written description.

(10 marks)

7. e) Based on your plan,

- Comment on the sources of external dilution, and give an approximation of the dilution rate expected.
- Comment on the sources of internal dilution, and give an approximation of the dilution rate expected.
- What do you expect will be the percentage recovery from this sector.

(4 marks)

Your Name ______________________

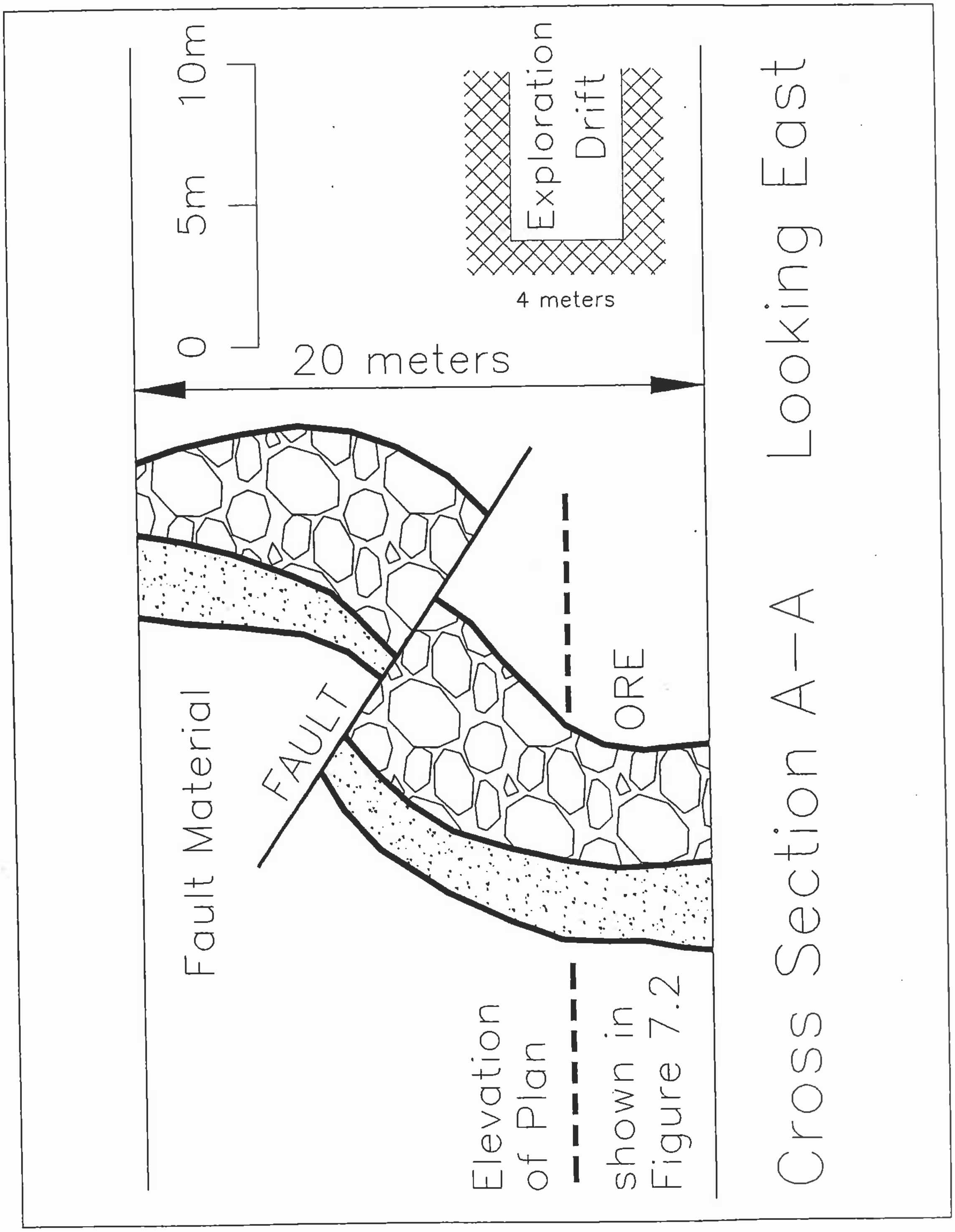

Figure 7.1 Cross section of a geological interpretation of a zone of interest which is 20m high. The horizontal thickness of ore varies between 3 and 8m, and the dip between 50 and 90 degrees. The 1 to 3m thick hanging wall fault and the 4X4m exploration drift are shown. A smaller cleaner fault displaces the top part of the mineralization downward toward the south.

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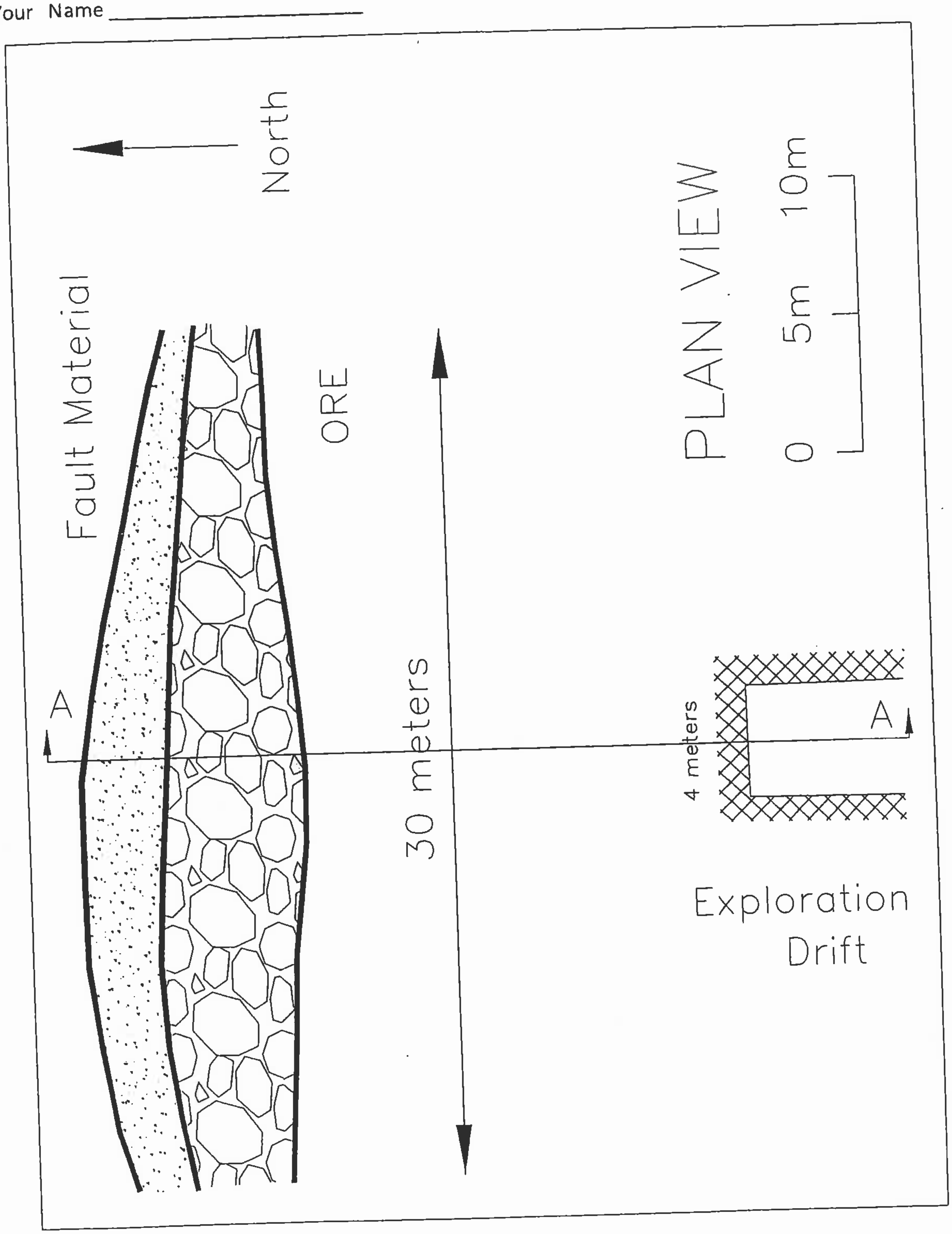

Figure 7.2 Plan of a geological interpretation of a zone of interest at the elevation shown by the dotted line in Figure 7.1. The horizontal thickness of ore varies between 3 and 8m, and the dip between 50 and 90 degrees. The 1 to 3m thick hanging wall fault and the 4X4m exploration drift are shown.

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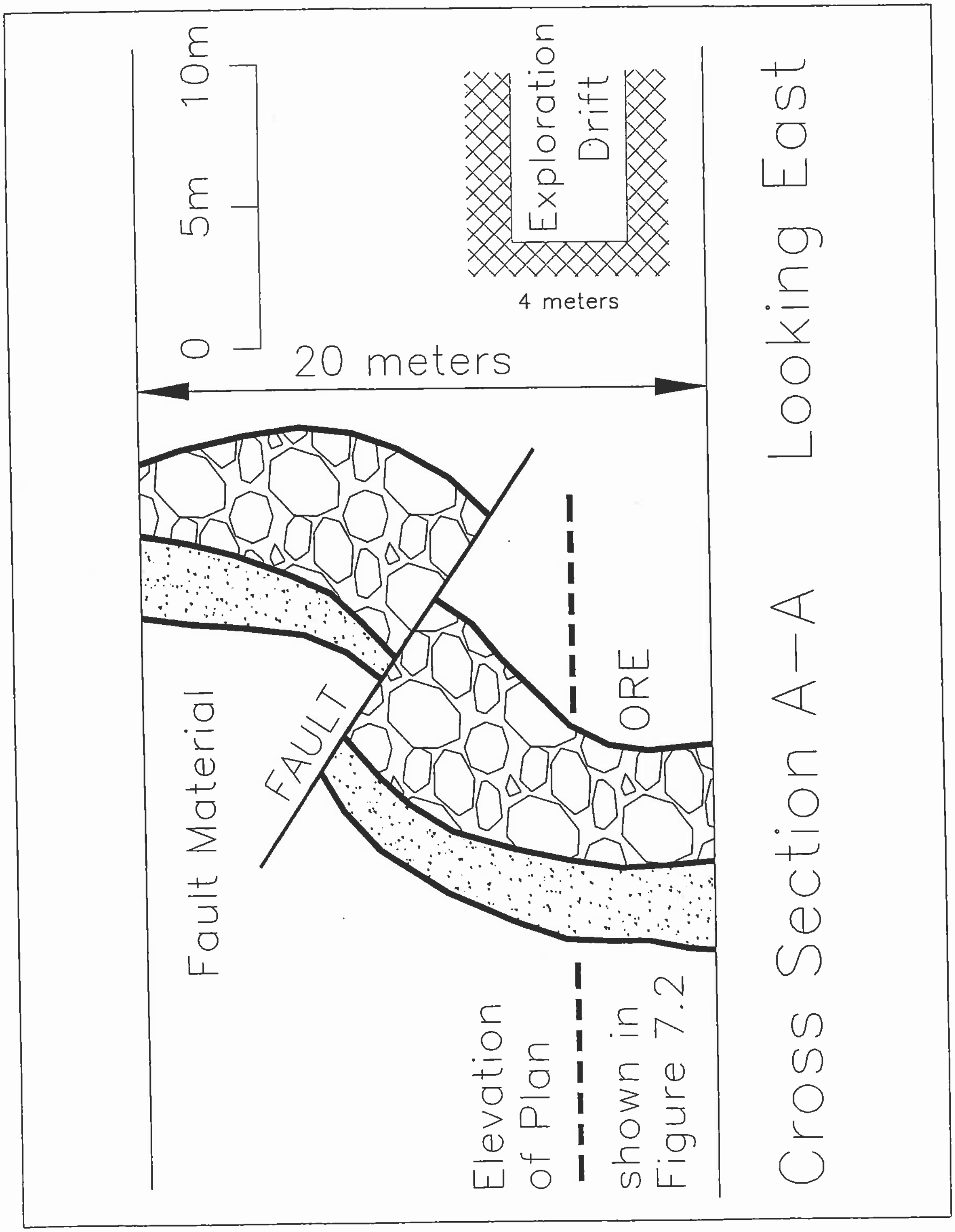

Figure 7.1.a Copy of Figure 7.1, a cross section of a geological interpretation of a zone of interest which is 20m high. The horizontal thickness of ore varies between 3 and 8m, and the dip between 50 and 90 degrees. The 1 to 3m thick hanging wall fault and the 4X4m exploration drift are shown. A smaller cleaner fault displaces the top part of the mineralization downward toward the south.

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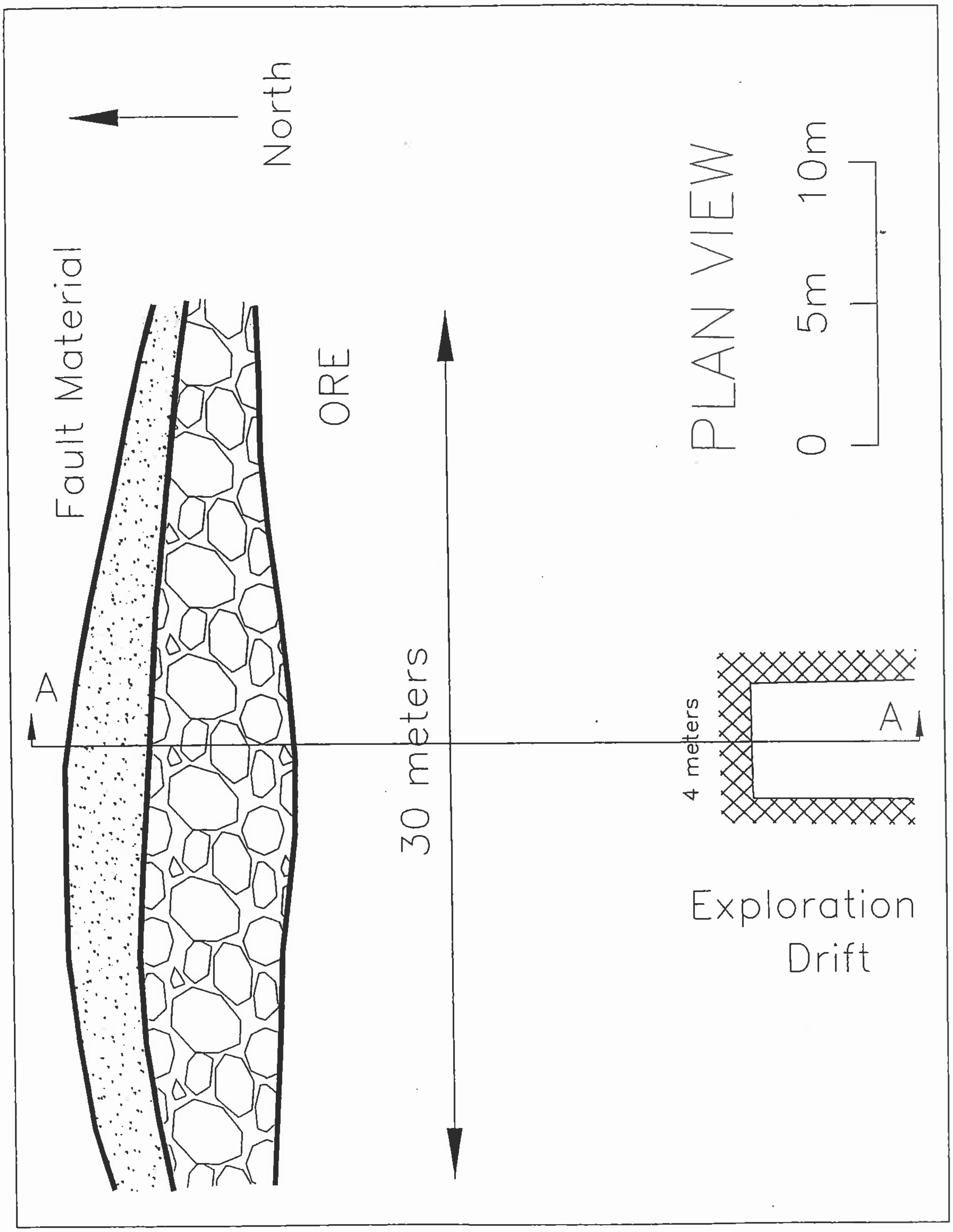

Figure 7.2.a Copy of Figure 7.2, a plan of a geological interpretation of a zone of interest at the elevation shown by the dotted line in Figure 7.1. The horizontal thickness of ore varies between 3 and 8m, and the dip between 50 and 90 degrees. The 1 to 3m thick hanging wall fault and the 4X4m exploration drift are shown.

End of Exam