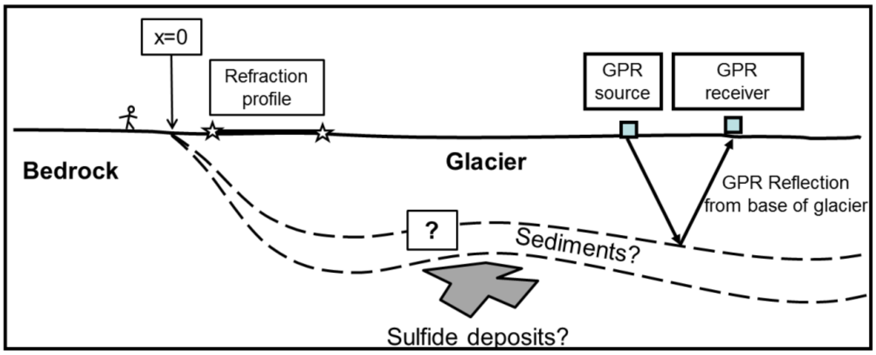
Introduction to problems 1 and 2



An economically challenged university in a cold and distant land hires this year's geophysical field course to the mining company CryoMines™. The company wants an exploration of a rather thin mountain glacier under which there may be sulphides in valuable quantities.

CryoMines asks the following questions:
a) Is the rocks below the glacier primarily crystalline rocks, or do we find thick sediments?
b) What is the thickness of the glacier?
c) Are there isolated occurrences of sulfides below the glacier?
This geological situation is outlined in the sketch above.

Field Course Team 1 examined the base of the glacier with the seismic refraction method. Problem number 1 below addresses this sub-study.
Field Course Team 2 examined the deeper parts of the glacier with GPR (Ground Penetrating Radar) and Team 3 examined the gravitational field. Problem number 2 below addresses these sub-studies.
The glacier has a horizontal surface. All data is measured along a profile perpendicular to the edge of the glacier. The profile reference point, x = 0, is located at the edge of the glacier.

Problem 1
Refraction data were measured with geophones along a 200 meter profile between x = 50 and x = 250 m. The source points (hammer points) were at x = 50 m and x = 250 m. Figur 1 and 2 show straight lines through first arrivals in the refraction seismic data for these two sections. The lines were extended as dashed lines across the whole section in order to make the reading of arrival times more accurate. Note that the time axis is pointing downwards. Note also that the values on the x-axis do not define distances from the source points but from the profile reference point.

1. Figure 1 shows a straight line crossing through the points (50 m, 0 s) and (250 m, 0.067 s). Determine the velocity in the first layer.

2. Determine the apparent velocity as well as the intercept times for the refected waves seen in each of the two sections.

3. Perform an interpretation using the two layer model with a dipping interface. Determine the dip of the interface as well as the velocity in the second layer and the distance to the dipping interface under each source point.

4. What can this study say in relation to question a) from CryoMines? We may expect the velocity of glacier ice to be between 2000 m/s and 3500 m/s. Sketch carefully your interpretation of these data in Fig 7.

Problem 2

Questions 1 and 2 relate to the study of GPR (Ground Penetrating Radar) data. Questions 3 and 4 relate to the interpretation of the gravity field.

1. Figure 3 shows a CDP (Common Depth Point) section at x = 400 m. Between 600 and 800 nanoseconds we see a reflections hyperbola. Please determine the rms velocity between the surface and the reflector.
2. Figure 4 shows the GPR reflection section between x = 50 m and x = 1300 m. GPR traces are shown for every 25 meters. Read the two-way time for reflections at the points x = 50 m and x = 400 m. Calculate the thickness of the glacier at these two positions, and plot these depths in Figure 7.
3. Figure 5 shows the Bouguer anomaly. It is measured every 50 meters along the profile. Figure 6 focuses on the interval around the local maximum.
   Please interpret the local maximum in Fig. 6 using a homogeneous sphere as the model body. Determine the center coordinates (x_0, z_0) and anomalous mass ΔM.
   In your assessment of the residual anomaly you may assume that the regional field is constant. Draw the interpreted position in Figure 7
4. Conduct a comprehensive assessment of the results of Tasks 1 and 2 focusing on the questions that the customer, Cryomines, asked:
   - What can we say about the presence of sediment under the glacier?
   - What can we say about the shape of the base of the glacier?
   - Is there evidence of localized bodies of massive sulphides below the glacier?
   - If so, what amounts of sulfide do the data suggest? It may be noted that the sulfides in outcrops in the area have densities around 4300 kg/m^3.