A SEISMIC REFRACTION SURVEY OF A COMPLEX ACCUMULATION IN ÄNGERSJÖ, SOUTHERN VÄSTERBOTTEN

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Abstract. Evidence of the formation of the complex ridge in Ängersjö has been compiled from seismic investigations and borehole data. The seismic data were obtained by using a hammer refraction seismograph, Model MD-3, as an adjunct to geological studies on the ridge.

The investigations show that the northern part of the ridge consists of a sediment deposit composed of well-stratified sand and silt. This sediment underlies a very loosely compacted, sandy to fine sandy till, which is thin in the northernmost part of the ridge but increases in thickness towards the south. In the middle and southern parts of the ridge, the seismic data indicate a loose till, which becomes very compact at a depth of 8 m in the southernmost part of the ridge. The average depth to bedrock along the seismic profile is 10.5 m.

A seismic refraction survey involves the determination of seismic wave velocities in, for example, different types of deposits. On the basis of other seismic data, it is possible to determine the depth to bedrock and the thickness of deposits.

The seismic velocity of a deposit is dependent on many factors, such as water content, porosity and grain-size distribution. Below the ground-water level, the seismic velocity of the different types of deposit increases by about 500 to 1000 m/sec. In addition, the seismic velocity in sediments seems to increase with the increasing coarseness of grain sizes (Fig. 1). Seismic surveys in Finland have also shown that the seismic velocity is directly related to the density of the type of deposit (Arhippainen and Korpela, 1964). This means that the highest seismic velocities are to be found in very hard and unsorted deposits, which are also situated below the ground-water level.

The investigated accumulation is situated in the Ängersjö area (locality 2 in Fig. 2), about 30 km south-west of Umeå in Västerbotten. This area is characterized by parallel moraine ridges of low relief, trending NNW.-SSE. The length of the ridges varies from 100 to 1500 m. There is often a bedrock core in the proximal part of the ridge and a tail of till in the distal part (crag-and-tail ridges). The till in the ridges has a sandy or fine sandy matrix (Johansson, 1972, p. 13).

The investigated ridge is approx. 1200 m long, 30—60 m wide and 2—5 m high. The seismic survey vas carried out along the crest of the ridge (Fig. 3).

Velocities between 280 and 350 m/sec were recorded for the uppermost seismic layer. These low velocities are characteristic of a dry, loosely compacted type of deposit.

In the middle and the northern parts of the ridge, the seismic wave was refracted towards an underlying layer with a velocity range of 540 to 660 m/sec. On the basis of the seismic velocities, the wave refraction may indicate (1) a more compact sandy-gravelly sediment, (2) a loosely compacted till or (3) a layer of stones and boulders in the deposit. On the basis of earlier investigations of ridges in the area, however, the wave refraction may indicate the change between wave-washed and non-wave-washed till.

A third velocity group was recorded along the whole ridge with a velocity range of 1000 to 1520 m/sec at depths of 1.5 to 3 m below the surface. This high velocity increase of between 500 and 1000 m/sec may

Sediment type	Seismic velocity m/sec
Clayey silt	970 - 1215
Silt	1150 - 1320
Sand	1270 - 1500
Coarse sand	1365 - 1640

Fig. 1. Investigated seismic velocities of sediments below the ground-water level. (After Thoregren, 1971.)

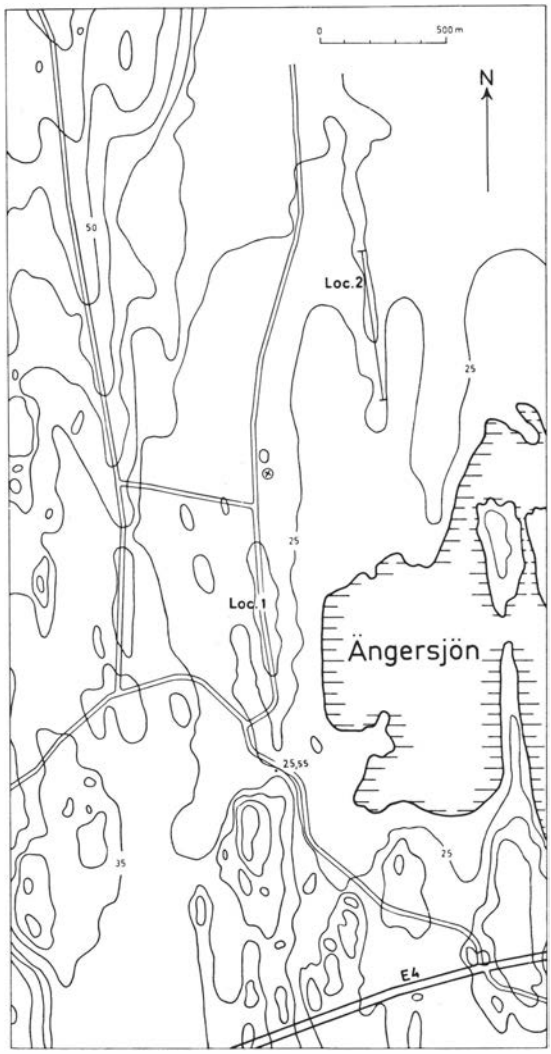

Fig. 2. The Ängersjö area. Contour interval 5 m.

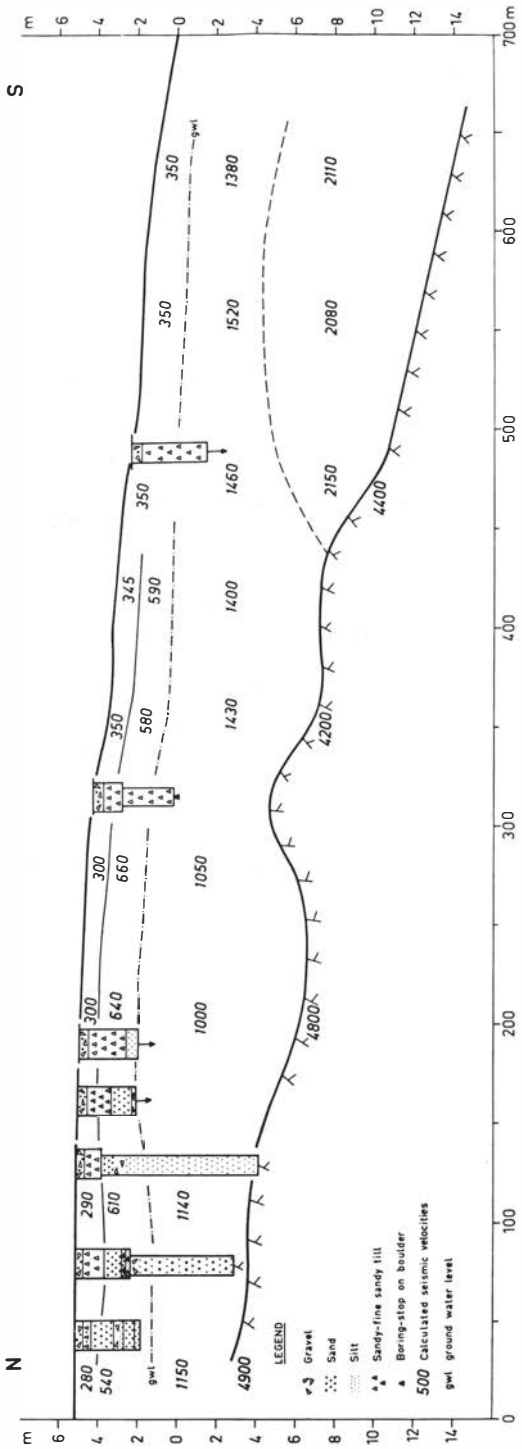

Fig. 3. The longitudinal seismic profile of locality 2 in Ängersjö.

indicate a refraction of the seismic wave at the ground-water level. This level agrees with data from other ground-water observations in the area.

In the northern part of the ridge, the recorded velocities in the third group are much lower than in the southern part of the ridge. These low velocities (1000 to 1150 m/sec) in a water-saturated deposit must indicate, not a till but a rather fine-grained sediment.

In the southern part of the ridge, higher velocities (1400 to 1500 m/sec) were recorded in the third velocity group. These higher velocities may indicate either a coarser sediment than in the northern part of the ridge or a loosely compacted till.

The fourth velocity group ranges from 2080 to 2150 m/sec and was recorded only in the southern part of the ridge. These high velocities are registered almost only in very hard, water-saturated till. The till may have a high content of boulders and stones.

The fifth velocity group indicates the contact between the bedrock and the overlying till or sediment. The bedrock velocities range between 4200 and 4900 m/sec. The average depth to the bedrock along the profile is 10.5 m.

Some complementary borings were carried out along the ridge. These borings indicated that the northern part of the ridge consisted of sediments with a thickness of about 8 m and composed of well-sorted, stratified sand and silt. The sediments underlie a very loose, sandy to fine sandy till with a thickness of about 1 to 2 m. The upper parts of the till are wave-washed. Both the till and the sediments contain layers of stones and boulders. These layers were probably the cause of the velocity increase in the second velocity group.

In the middle and the southern parts of the ridge, the thickness of the till increases towards the south. No sediments have been found, although continued borings were made to a depth of 4 m.

It is concluded that the identification of different sediments and till in the complex ridge based on the recorded seismical velocities corresponds well with the data from the borings. The seismically recorded depths to the ground-water level and to the bedrock also correspond with the boring depths.

REFERENCES

Arhippainen, E. and Korpela, K. 1964. Maaperän kaivettavuuden määrittäminen kaivuvaikeusluokan perusteella. *Rakennustekniikka* 1964:11. (Schaktbarhetsklassificering som hjälp vid bedömning av maskiners schaktförmåga. Översättning till svenska av Jüri Martna. Den svenska översättningen ingår i *Statens Vattenfallsverks Meddelande No.* 1528.)

Johansson, H.G. 1972. Moraine ridges and till stratigraphy in Västerbotten, northern Sweden. *SGU,* C 673. Stockholm.

Thoregren, U. 1971. Kvartärgeologiska undersökningar med hammarseismograf modell MD-3. *Forskningsrapport från Geologiska inst., Kvartärgeologiska avd., Uppsala universitet, No.* 11. Uppsala.