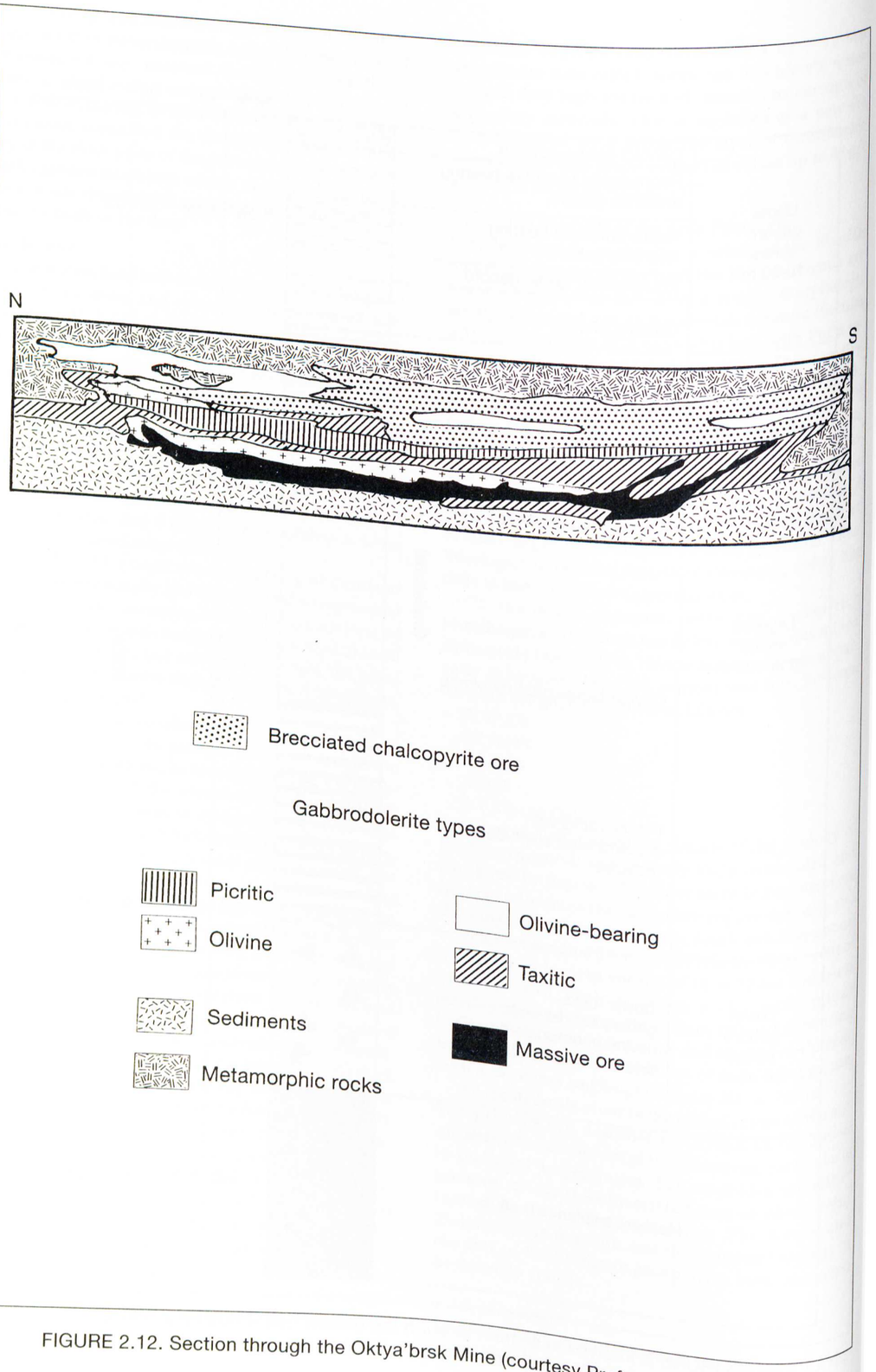

FIGURE 2.12. Section through the Oktya'brsk Mine (courtesy Professor M.J. Viljoen)

deposit (Figure 2.13) which, with its intrusion, extends 20 km along the Noril'sk-Kharayelakh fault and up to 7 km away from it. The Talnakh deposit consists of two superimposed intrusions; a chromite-bearing upper sill, and a chromite-free lower sill a few tens of metres below it. The lower sill contains only disseminated sulphides and no PGE, and cannot be classified as ore. The Noril'sk ore junction to the south contains the Noril'sk I and II, as well as the Mount Chernaya orebodies. The Noril'sk deposit also has a lower differentiated sill a few tens of metres below the main sill and 5 to 10 km west of the Noril'sk I orebody. The South Noril'sk deposit contains the Burkan and Zelyonaya Greva differentiated sills, but no details of any ore are available. The Imangdinsky ore junction to the east has five differentiated sills, and the Talminsky junction has six, of which two — the Kalminsky and the Klukvenny — are known to be differentiated.

The almost impenetrable mystery that has surrounded all Russian ore deposits in the past (in all available Russian literature, no orebody plan or section contains a scale), has led to wide speculation concerning the grade of the Noril'sk-Talnakh deposits. Newman (1973) suggested that the massive ores contains 9,7 g/t PGE, and the disseminated ores 3,5 g/t. Buchanan (1979) postulated an overall grade of 3,8 g/t. Lines (1979) suggested that the grades of the Mayak and Komsomolsky mines were 3 per cent copper, 1,5 per cent nickel, and up to 11 g/t PGE, and that of the Oktyabr'sky mine between 2,5 and 3,65 per cent nickel, 4,7 per cent copper, 0,13 per cent cobalt, and some PGE. Von Gruenewaldt *(op. cit.)* recognized a variety of grades for the Talnakh mines: for massive pyrrhotite–chalcopyrite ores, 3 per cent nickel, 4 per cent copper, and 25 to 30 g/t PGE (Pt:Pd ratio 1:3); while the copper-rich ores, commonly at the extremity of orebodies, contain up to 40 g/t PGE; disseminated ores contain 0,3 per cent nickel, 0,4 per cent copper, and 5 g/t PGE. The newly discovered orebody in the upper zone, described above, reportedly assays 40 g/t PGE (Pt:Pd ratio 1:4,2). The 1992 Platinum Review (Johnson Matthey) suggests that PGE grades vary between 5 and 15 g/t, with local grades up to 60 g/t. According to Naldrett (1992), the massive ore in the Oktya'brsk mines and the Taimyr mine measures 1 by 3 km, with an average thickness of 20 m (270 Mt, assuming a density of 4,5). The central part of the orebody contains 3,78 per cent copper, 3,72 per cent nickel, 1,3 g/t platinum, 6,3 g/t palladium, 0,19 g/t rhodium, and 0,014 g/t iridium, while the strongly zoned copper-rich portion contains 27,4 per cent copper, 2,5 per cent nickel, 8,8 g/t platinum, 35,2 g/t palladium, 0,4 rhodium, and 0,04 g/t iridium. There are therefore many different interpretations of the grades of these deposits.

While I was on diplomatic service in Europe from 1986 to 1990, I obtained the data contained in Tables 2.10 and 2.11 from an unofficial source who requested absolute anonymity. These data remove much of the uncertainty concerning grades based on large ore tonnages. Unfortunately, the age of these data is uncertain, but it is thought that they refer to 1980.

The report by Von Gruenewaldt *(op. cit.)*, after his visit to Noril'sk, provided very interesting information on the orebodies, obviously provided by his hosts. The same data were also provided to Professor M.J. Viljoen during his visit (personal communication, 1993). This suggests that the Talnakh intrusive covers an area of some 80 km^2, its disseminated ores an area of some 60 km^2, and its massive ores an area of 32 km^2. Careful measurement of the areas using a planimeter could confirm only the area of the intrusion contained within the various mines and the area underlain by the disseminated ores. The massive ores appear to underlie an area of only some 19 km^2. Either the figure of 32 km^2 is a misinterpretation, or the areas of massive ore shown on the plans are erroneous. In the present work, the figure of 19 km^2 has been used, for which details are provided in Table 2.12.

The areas of the orebodies in Table 2.12 have been tied to the ore-tonnage information in Table 2.10, which suggests that the massive orebodies, reportedly 40 m thick, are certainly few and far between, and probably represent those rare ore showings selected especially to impress mine visitors. Table 2.10 refers only to Pt+Pd, so the PGE values have been calculated from the PGE distributions (Figures 2.10 and 2.15) for each mine (Table 2.13 — interested readers can easily calculate them from the ore-tonnage distribution). The grades provided in Table 2.10 are millhead grades from which *in-situ* grades were calculated (1,25 times the millhead grade). The results are shown in Table 2.13. Mine production was calculated from data supplied by Sutphin and Page (1986) using their annual production information (17,8 Mt/y), applying the average overall ore grade and PGE distribution of all the orebodies to that tonnage and calculating the cumulative production from 1980 to 1992.

It is not known whether the available orebody data includes the reportedly newly discovered PGE-rich ore layer in the upper zone. If, as is probable, this orebody is not included, the PGE potential of the Noril'sk-Talnakh ore is much higher than that calculated.

For the Pechenga deposits of the Kola Peninsula in Russia, Sutphin and Page (1986) provided resources of 128,1 Mt grading 2,1 per cent nickel and 3,8 g/t PGE in the year 1980. They estimated production (based on 1977 values) to be 17,8 Mt/y. If this production has been maintained, then the ore at those deposits has now been exhausted and need not be considered any further.

2.3. Finland

Large numbers of variously sized nickel–copper deposits occur in Finland. Papunen (1988) recognized three groups: Archaean deposits (c. 2800 My); early Proterozoic layered intrusions (c. 2240 My); and the Outokumpu-type ultramafic complex of northern Karelia (c. 1970 My), the Svecokarelian ultramafic-mafic intrusions (1990 to 1860 My), and the post-Svecokarelian dolerite dykes (1959 to 1560 My), for which no details are available.

Of the Archaean deposits, only the Hietaharju de-