There is little change in patterns of pressure distribution at an elevation of ±0 masl (231.44 m depth) between Stage-13 and Stage-16. Pressure drop areas develop around the shaft below an elevation of -400 m. The difference in pressure distribution among the three models is not as large as in the shallow part. It is probably because this section is in the “Moderately fractured zone”, has fewer fractures and especially fewer fractures with large diameters.

(4) Summary

Results of the construction of the hydrogeological model and groundwater flow simulation are summarized as follows.

① In the 2nd analysis loop, homogeneous, truncated power law and negative exponential models were constructed. They were constructed on the basis of the data on fracture distribution and hydraulic conductivity obtained in the 1,000 m-deep MIU-1, 2 and 3 boreholes drilled inside the Shobasama Site. The truncated power law model is more dispersed in fracture diameter than the negative exponential model, that is, it contains fractures with larger diameter. The negative exponential model is aimed at a better reproduction of the heterogeneity in measured hydraulic conductivity and is characterized by a lower 1-D fracture density.

② No remarkable difference is found in groundwater flow prior to the shaft excavation between the homogeneous model (no fractures taken into consideration) and truncated power law model and negative exponential model (taking fractures into consideration).

③ The shaft excavation generates a conical pressure drop field around the shaft in the homogeneous model. On the other hand, it generates irregular pressure drop fields along the fractures in the other models. There is no large difference in effects of the shaft excavation in the “Moderately fractured zone” between the homogeneous model and the other models.

④ No effect of shaft excavation extends to the north side of the fault until the shaft penetrates the fault. After penetration, a pressure drop forms on the footwall side (north side) of the fault. The extent of the effect depends on the distribution of fractures. The present simulation indicates that an “equivalent continuum model” (model which takes the heterogeneities into consideration) has a more restricted extent of pressure drop. It probably results from the heterogeneities of hydraulic conductivity.

⑤ The “equivalent continuum model” allows representation of the fracture distribution (direction, density, size and permeability) in the hydrogeological model. Therefore, the “equivalent continuum model” can reproduce the low permeability of the Tsukiyoshi Fault, and is applicable as a methodology for evaluating the groundwater hydrogeology of a several km^2 area.

4.2.4 Future tasks

The results of the 1st analysis loop allow overall understanding of groundwater flow. However, their comparison with the measured values obtained through the subsequent borehole investigations indicated a large discrepancy in the head distribution in the granite. Furthermore, an important task recognized was to determine the cause of the discrepancy and the prioritization of data acquisition in order to reduce the uncertainty of the simulated results.

The 2nd analysis loop, including a groundwater flow simulation supplemented with data obtained by three borehole investigations, produced excellent results by application of an "equivalent continuum model". It makes the prospects better for more realistic hydrogeological models and groundwater flow simulations. It indicates that the study approach toward the systematization of methodologies and techniques for investigation, analysis and assessment are coming along well. Results of the past hydrogeological investigations indicated that sufficient data allowing a statistical processing can be obtained to advance model construction and groundwater flow simulation more effectively in the future. However, the present state is not yet satisfactory. Thus, planning the future investigations requires dealing with and resolving the uncertainties.

At the end of the reporting period, the 3rd analysis loop is to begin. In this loop, construction of the hydrogeological model is in progress on the both continuum and discontinuum, using a methodology of comparative analysis. The results of these investigations are planned to be evaluated through comparison with results of long-term pumping tests scheduled in 2001 FY and the subsequent observation on effects of the shaft excavation.

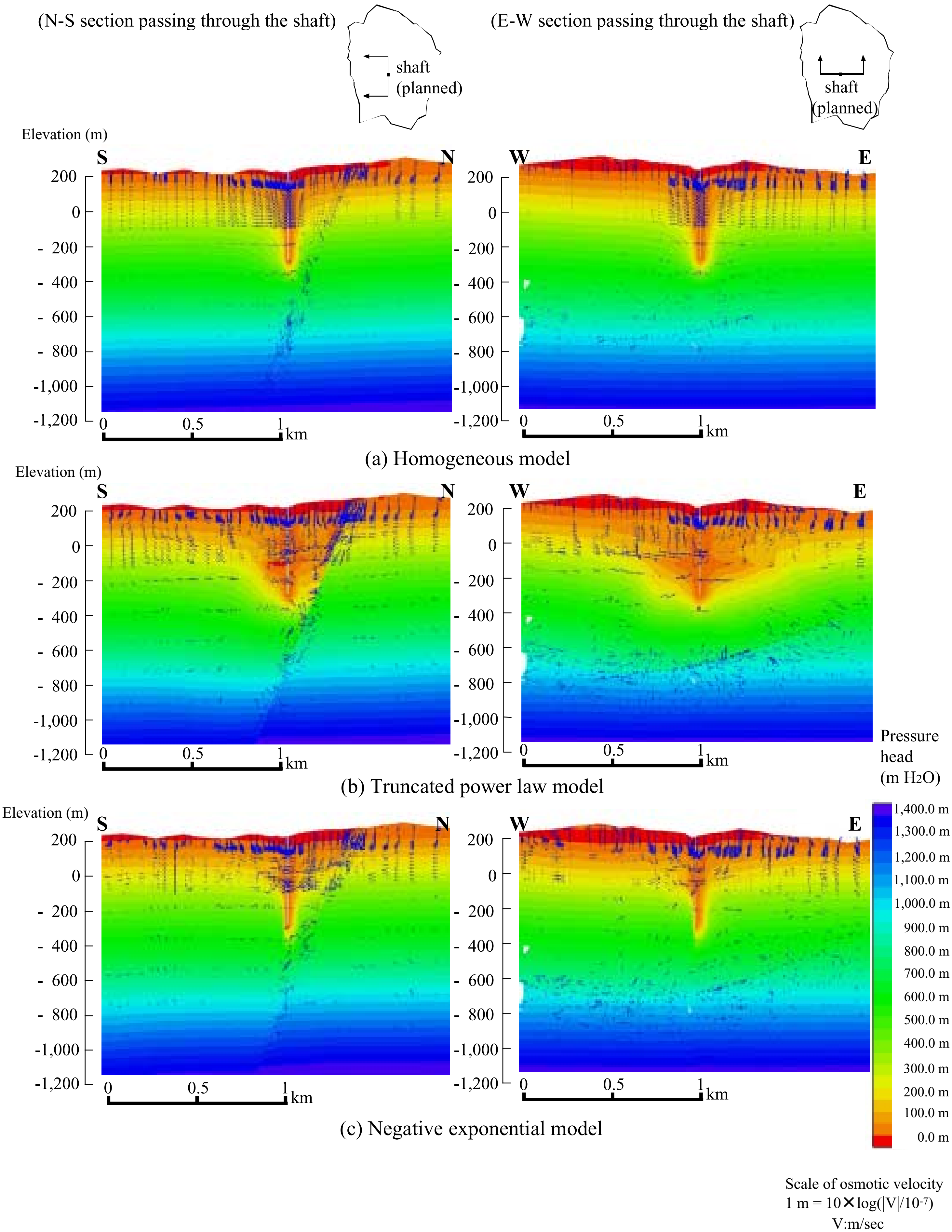
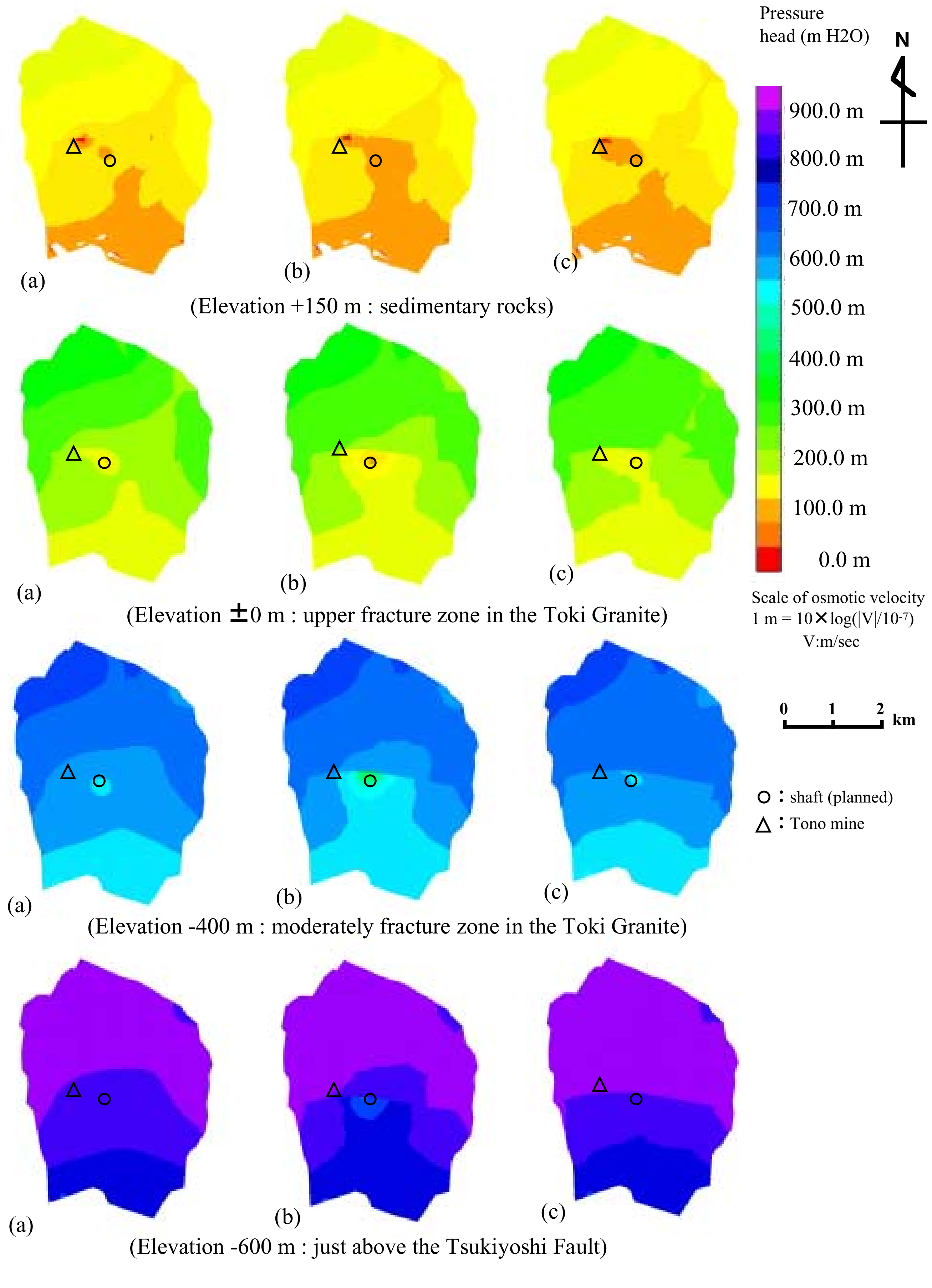


Figure 4.55 Pressure head in vertical section during stage-13 (508.5 mbgl in depth)



((a) Homogeneous model, (b) Truncated power law model, (c) Negative exponential model)

Figure 4.56 Pressure head in horizontal section during stage-13 (508.5 mbgl in depth)

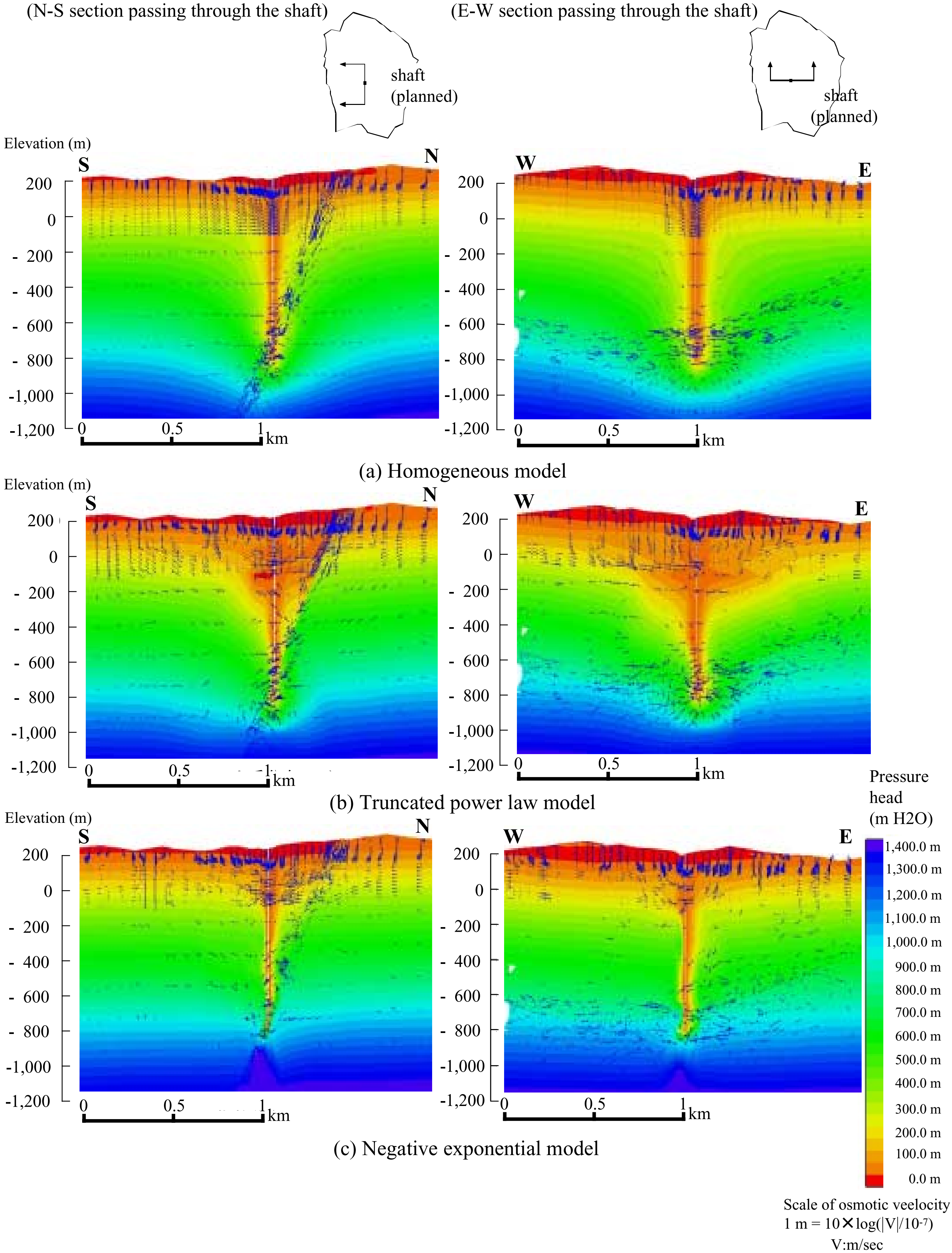
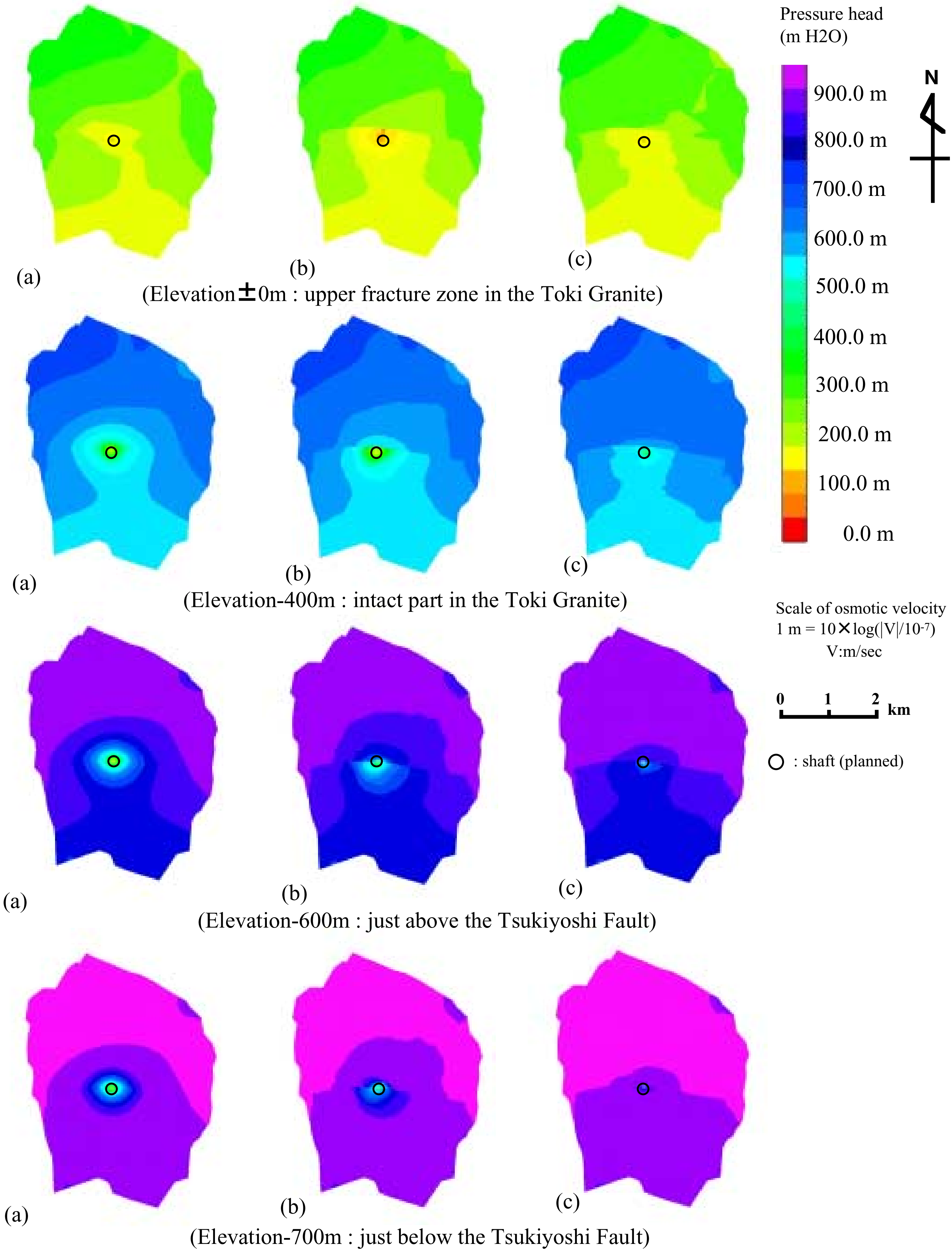


Figure 4.57 Pressure head distribution in vertical section during stage-16 (1,001.4 mbgl in depth)



((a) Homogeneous model, (b) Truncated power law model, (c) Negative exponential model)

Figure 4.58 Pressure head distribution in horizontal section during stage-16 (1,001.4 mbgl in depth)