Direct determination of the rate of seawater intrusion with noble gases

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ABSTRACT
This study deals with the determination of seawater intrusion rates in the Israeli coastal aquifer using a wide range of dating techniques with focusing on the novel analyses of noble gases (^{39}Ar, ^{85}Kr, ^{3}He-Tr). Several studies have recently tried to estimate the velocity of seawater intrusion by dating groundwater with radiocarbon and tritium. However, age interpretation based on both of these methods is considered equivocal as radiocarbon is often affected by water rock interactions and in recent years tritium concentrations have reached low and almost constant values due to its relatively short half-life (12.4 years). Determining groundwater ages by radioactive noble gases has a potential to be highly accurate and relatively easy to interpret as no correction for water rock interactions are needed.

Water samples were collected from 5 boreholes situated along a cross section perpendicular to the shoreline, at distance of 30 to 700 meters from the sea. These boreholes penetrated below the fresh-saline water interface allowing for sampling the intruding seawater for noble gases, radiocarbon, tritium, CFCs and SF6. Since the samples often contain a component of freshwater, the seawater fraction was carefully calculated in order to derive ages for both components. It is interesting to note that in some places the ages of the shallow fresh groundwater were older than the deeper saline water.

Preliminary results: Ar-39 (half-life of 269 years) provided an age of ~270 years (50% of the atmospheric value) for saline groundwater at distance of ~700 m, suggesting an average horizontal intrusion rate of ~3m/yr. This is in accordance to preliminary age estimation based on Ra isotopes. Similar rates (~4 m/yr) were found at a distance of ~200 m using the short-lived Kr-85 (half-life of 10.756 yr) and the Tr-He method. In addition, CFCs and SF6 provided further support to the young ages (in the order of a few decades) for the boreholes located up to a distance of 200 m from the seashore.

A systematical comparison between the various dating methods is still required in order to better understand the reliability of each technique in predicting the groundwater ages for the case study at hand.