University of West Hungary

THESIS of PhD DISSERTATION

Potentialities of the Sonar Method for Detecting Drawn Springs

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Sopron
2005.

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Motivation

In 2001 the author was involved in the sonar measurements for investigating the morphology of the river bed in the vicinity of the location where the proposed DBR4 metro line (Budapest, Hungary) crosses the river Danube. The sonar sections showed some wave arrivals, which greatly surprised the specialists. Those phenomena were considered to be reflections from hot drawn springs.

Objectives

Drawn springs are springs rising below the surface of a day water such as a river or a lake. Prospecting for such springs was started more than 100 years ago. Even so, up till now drawn springs have only been known near to river banks or the shores of lakes and in the shallows. The main reason for this was that in lack of other effective methods the only way to detect them was direct observation.

The main objective of the dissertation is to prove that it is possible to detect hot drawn springs in the cold water of the river Danube by the reflection of acoustic waves, thereby providing geophysicists and geologists with an effective method for investigating this type of spring. The second goal is to map those drawn springs with considerable discharge by using existing sonar data and then to compare their location with what is known geologically.

Brief description of the work

The above-mentioned objectives require that the temperature dependence of the main acoustic (seismic) parameters, the density, and the longitudinal wave velocity should be comprehensively investigated. The parameter contrast caused by temperature differences was taken into consideration for mathematical and physical modelling to prove that there is no theoretical or practical difficulty in detecting drawn springs.

The dissertation summarizes the literature about drawn springs and the sonar method, and discusses the connection between recent geological and hydrogeological knowledge and the location of the supposed drawn springs.

Those types of drawn springs that are considered to be characteristic are illustrated by sonar sections, and drawn springs with considerable discharge are represented on the location map.

New scientific results

1. Calculations were carried out using data from the literature on a two-layer step model to prove that the different velocity and density caused by the different temperature of drawn springs and the water of the river Danube results in reflection of the acoustic waves, and that the sonar method is theoretically suitable for detecting drawn springs. It was demonstrated that gases discharging from the incoming hot water can increase the reflection coefficient by as much as one order of magnitude thereby increasing the probability of detection.

2. A modelling program was created using the hyperbolic superposition method. This program meant that it was possible to prove that even by taking into account the mixing effect, reflections with measurable amplitude can be recorded backscattered from the hot water of the drawn springs in the Danube. Calculations of transition zones with different dimensions were repeated and the resulting waveforms were investigated. It was demonstrated that if the frequency and the footprint of the piezoelectric source and receiver used in the actual measurements are taken into account, the reflections and their decrease with increasing distance can be clearly seen on the synthetic seismograms.

3. Control and measuring program was created for the data acquisition system which can set the acquisition parameters (sampling rate, record length, number of channels etc.), display on the screen and record the sonar

data in regular seismic format. The GPS coordinates and some special markers can be inserted into the header. This program was applied during all sonar measurements.

4. By physical modelling using the same instrumentation as for field measurements it was clearly demonstrated that a temperature difference of 5 °C produces reflections with measurable amplitude. The temperature difference in the actual measurements on the river Danube was expected to be 35 °C; in other words, there is no reason not to get reflections from the drawn springs. Tests were done to check whether or not the plastic bags used to hold the water of different temperatures under the profile influence the reflections. It was proved that even if backscattering originated from the plastic bags, the amplitude of the reflections from the water inside them was significantly, about 5 times, greater.

5. By means of sonar measurements more than 50 unknown drawn springs were discovered in the Danube, south of Szabadság Bridge: most of them were in four separate groups but there were some scattered ones. In most cases other interpretation possibilities could be discarded by careful analysis. The existence of drawn springs can be verified by the fact that from the geological point of view they are in logical locations, viz. where the potentially aquiferous fractured rock is on or near to the river bed.

Applicability of the results

Knowledge about the location of drawn springs can be used directly during the construction of Budapest`s proposed 4th metro line to prevent possible water inrushes and to enable the hot water systems and the spas of the city to be protected.

The method - validated by mathematical and physical modelling and actual measurements - is general and makes it possible to detect drawn springs not only in the river Danube but in other day waters as well. In this way more information can be obtained about Budapest`s hot water systems thereby making it easier to prevent damage to or pollution of the hot springs.

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