New Water for a Thirsty World by Salzman_Excerpt

In the Pacific Palisades section of the city of Los Angeles, at an elevation beyond the point to which the city's water supply lines went, Riess located two primary water wells of excellent quality.

Today, Riess is engaged in locating primary water under the terms of a five year contract with the San Bernardino Valley Municipal Water District, which comprises several cities the largest of which is San Bernardino, California with a population in excess of 90,000.

Excerpt from Salzman Book regarding: E. NORDENSKIOLD who was nominated for a Nobel Prize – Pages 57-71

Diligent probing in hydrologic literature had failed to uncover any predecessor in the Riess method of locating water by intercepting fissures in solid rock. One day after I had, at quite some length, explained Riess' work to him, Dr. Linus Pauling surprised me by saying that Riess' successes reminded him of the Swedish mineralogist Nordenskiold who had been nominated for a Nobel Prize for his ability to locate fresh water in the solid rocks.

I was elated, a possible antecedent had been found. Research on Nordenskiold proved to be an exciting experience, inasmuch as I was feverishly attempting to ascertain whether the resemblance would prove to be a true counterpart. In addition to material found locally, there was correspondence with the Nobel Foundation and the Swedish Academy of Sciences.

Adolf Erik Nordenskiold was born at Helsingfors (now Helsinki), Finland, on November 18, 1832. He was the son of Nils Gustav Nordenskiold, a mineralogist, traveller, and head of mining in Finland. During 1853 to 1857, Adolf visited Berlin where he engaged in research in mineral analysis at Rose's laboratory, after which he settled in Stockholm and there became Professor of Mineralogy in 1858. Later he became a prominent arctic explorer and was knighted by the King for his explorations.

Nordenskiold's nomination, made by Dr. P. E. Sidenbladh, a member of the Swedish Academy of Sciences, was for his ability to find drinking-water by drilling through solid rocks into rock fissures. Nordenskiold died on August 12, 1901, before the Academy of Sciences had convened on the question of prizes so that his candidacy never really materialized. [74]. It is safe to say, just as Gorman's statement concerning the published report by the two Indian physicians, that an article by Nordenskiold, if presented before an audience of ground water hydrologists, would also be hailed as something new, something they hadn't studied about, hadn't practiced, and hadn't even known about, despite the fact that this article was published in 1896 and was the basis for his nomination as a candidate for the first Nobel Prize in Physics.

Nordenskiold located and had drilled thirty-one wells in the primary or primeval rocks of Scandinavia and in every instance found the fissure he was looking for. All but one of the fissures contained water, the one exception contained only clay. In the light of the work done by Riess, it is interesting to read Nordenskiold's account even though the fissures he found were at about one hundred feet below the surface, quite shallow compared to those located by Riess. Nonetheless, many of Nordenskiold's experiences bear similarities to those of Riess, and the water found by both constitute high quality potable water. Nordenskiold's article [75], translated by the author, follows.

ABOUT DRILLING FOR WATER IN PRIMARY ROCKS

By A. E. Nordenskiold

Drilling in our primary rock for supplies of water has now been going on for two years, during which time twenty-eight well holes had been finished. Perhaps it may be appropriate to give our geological society a review of the results obtained and thereby give its members the opportunity to test the correctness of the assumptions upon which this work was based, and the legitimacy of the deductions I have derived therefrom.

It is no mere question, here, of someone who is more or less successful in drilling for water, but a fresh new principle within geology, not only of enormous importance from both a hygienical and economical standpoint, but also of sweeping theoretical significance able to correct the theoretical construction of geology. Specifically, by this construction there must exist a great difference between primary rock, in which all formation ceased a long time ago, and primary rock in whose interior an everlasting circulation of water takes place. There, a continual process, even though slow, of displacement of layers and the new formation not only of calcite, 58 but also of quartz, feldspar, prehnite, augite, pegmatite—and other silicates can continually be observed. In a figurative sense, it reconciles to this summation, one primary rock dead since a million or forty million years ago, the other primary rock with vitality and a day to day evolution.

It is my desire to bring up the difficulties and questions surrounding the first drilling attempt to obtain usable drinking water on the various rock-bound or smaller islands on which beacon lights are situated and for pilot stations near the coast. In connection with this, I remember an observation of my father, Nils Nordenskiold, who was chief of mining in Finland and who died in 1866, that salt water did not penetrate the iron mines situated near the Finnish coast and which were beneath sea level, despite the fact that there was always, more or less, what miners call bad water. Part of an observation I made during the years 1861 and 1864 on an expedition to Spitzbergen, where on a walk I came across a strongly folded and reversed tertiary layer resting on a perfectly horizontal permo-carbonstratum. This later observation I recorded in "Sketch of the Geology of Spitsbergen" in the following way:

> The strata of the mountain-limestone which, at Hinlopen Strait, alternate with plutonic rocks, are almost horizontal; but the Tertiary beds at Kings Bay and Cape Staratschin are, on the contrary, quite folded, notwithstanding no eruptive rock could be discovered in the vicinity, excepting a little vein of diabase (?) at Cape Staratschin.
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> There must, consequently, be some other reason for the folding occurring in these places; and it appears to me that too much importance has been generally ascribed to the influence of the eruptive masses in connection with the folding, upheaval, and dislocation that is almost everywhere observed in the earth's crust. As is the case with innumerable other geological phenomena, this, also, very likely results less from any violent revolution than from some almost imperceptible but nevertheless continually operating power. The upper part of the earth's crust is, of course, subjected to periodical variations of temperature, which, at Stockholm, for instance, at a depth of seventy or eighty feet, rise to 0.01°C. If the earth's crust were continuous, and the change of volume, caused by these variations of temperature, did not exceed the limits of elasticity of the rock, they would not exercise any disturbing influence. But as to a greater or lesser degree, there are in all mountains fissures and clefts, these will widen in lower temperature, but become narrower as soon as the temperature rises. If however, as may often be the case, the fissures when enlarged by lower temperature are filled up either with chemical or mechanical sediments, a powerful lateral pressure will naturally ensue when the temperature again rises and extends the rock; and thus every variation of temperature will cause a 59 slight dislocation of the strata. When we consider that this agency is working from year to year, in the same direction, and that the extensive movement of many hundred miles of the earth's crust may cause folds only at some narrow spot where the resistance is a minimum, it should not surprise us to find even the newest formation gready reversed, whereas old formations in the vicinity, may be quite undisturbed.

Upon reflection, the above advanced outline is correct, and therefore a horizontal displacement fissure ought to generally occur in every solid species of rock at relatively slight depth under the surface of the earth. Probably these fissures are conveying water. If so, in our primary rock one likewise ought to be able to obtain water through a bore hole to these fissures. But how good is this water on promontories and islands skirting a coast, the only prospective places to have to attempt such drilling? This was the question faced upon such an undertaking. Relative to its practicableness, in 1885 I had already concerned myself to obtain some further data before passing judgment on this question, when several private persons and authorities jointly made inquiries touching on the salinity of waters in wells and mines near the seacoast. In connection with this, I received much valuable information. Mineral surveyor Anton Sjogren wrote as follows in this note of September 30, 1885.

> The following mines have reached the indicated approximate depths below sea level:
>
> Meters below sea level
> Finnmossen 15
> Taberg i Vermland 90
> Nordmarken 15
> Uto 120
> Dannemora, Mellanfaltgruvan 192
> Dannemora, Sodra faltgrufvan 180
> Bersbo, Atvidaberg 390
> Mormorsgrufvan, Atvidaberg 300
> Falu grufva 222
> Kallmora grufva vid Norberg 15
> Sala 270

Relative to questions on mine water salinity, I never knew the water in our iron mines to be other than salt free. In your letter you ask questions as to whether mine water contains the salts that occur in sea water. I believe that we are thus agreed that these questions can be answered with no.

Lord-lieutenant C. Nordenfalk communicates that many wells, 60 found in Hallandia (in sedimentary layers) in close proximity to the seacoast, give this salt free water, notwithstanding that it comes from a depth of thirty to seventy-five meters below sea level. In a well that was also drilled in loose sedimentary stratum, at the square in Jungsbacka, produced ample water that comes 3 to 4 m above sea level, but this water is salty. To conclude, these questions are taken up and discussed in Geologiska Foreningan (se dess forhandl, 1891, s. 13, 143 och 296).

From the knowledge that was obtained in this manner, even though only slightly decisive, that this water that could be obtained at depth by drilling in our rocky archipelego would not consist of sea water devoid of potable fresh water, I therefore proposed to the then chief of the pilotage branch of the Board of Admiralty that some suitably located pilotage station permit the conducting of a drilling attempt in a specifiable location.

It was for this reason that the first drilling for water in our primary rock was attempted in 1891 on the little Svangen south of Kosterfjordan. Drilling was given up before sufficient depth was attained because they thought that a fissure leading in from the sea stretched itself to the well hole. The place for drilling had not proven to be selected by a person competent to judge, and the work supervised, if I know, not by someone who believed in the possibility of success. Hence the presumably hasty abandonment of the work.

After that, the question was pigeon-holed and inactive for some years; it was ended until taken up by the Director General of the Pilot Service, Baron Ruuth, who except for considering the reputed unsuccessful drilling near Svangen light agreed to conduct a new drilling attempt at Arko near Braviken. Craftsmen made the drilling spot (a)* level, directly near the pilot station, located on a ledge of rock on a hill a couple of meters above the sea. The species of rock was composed of hornblende leaded gneiss and diorite. The outcome was particularly favorable, in that soon after a depth of 35.5 was attained, 450 liters per hour of first-rate good water was produced.

The drilling hole had a diameter of 64 mm. The water conveying fissures lay at 32-33 m depth below the opening, (b)* The water, at the beginning, was a little yellowish, having been mixed up with borings and with mud from the water conveying fissures, but after a short time perfectly clear, and besides which the amount of water increased. With at least the possibility of water veins occurring in primary rock entirely proven—and certain difficulties avoided through improved drilling technology developed in drilling beyond the sands in our mines, the "Diamond Rock Drilling Company" received orders for new well drilling. Drilling for water in our primary rock was executed and proven in the following places, by this writer, which are here given in chronological order.

*a) For this purpose the place was visited, in the beginning of May 1894, with me by geologist Svenonius, graduate G. Nordenkiold and Director Casselli. 61

1. Arko. Species of gneiss, hornblende gneiss, etc. Well-hole depth 35.5 m. Diameter 64 mm. The water bearing fissures were reached here, just as in most of the well holes, at a depth of about 32 m. Abundant supply of first-rate good water, which still was a little hard. This water was used for purposes common to drinking water and all sorts of cooking, not only by the population near the pilot station but also by vessels that lay to near the pilot station.

2. Stockholm; Saltsjobaden. Gneiss mixed granite. Well hole depth 35.5 m. Diameter 64 mm. Abundant supply of good water. With reference to blasting with dynamite near the mouth of the well hole, surface crevices originate, that possibly can carry dirt to the well hole. Temperature 4-7°.

3. Stockholm; Tacka Cape. Depth 35.5 m in hard Stockholm granite. Diameter 64 mm. Abundant water. The water still continually mixed up with a yellow clay and possibly fouled by muddy water from an adjacent garden plot. Considerable dynamite blasting was precluded by well cleaning. Nevertheless, after several days of

*(b) The water has always been found at a depth of 30 to 35 (generally 32-33) m under the rock surface, but the drilling usually continues a couple of meters under the water bearing fissures, which drillers recognize because the rock there is "in tatters." In a few places, without my knowledge, the drilling continued "out of curiosity" to a considerable depth. Any increase of the water supply has never been obtained in this manner. On the contrary, this drilling below the water bearing fissures had the disadvantage that a quantity of dirty water is pumped in, which with difficulty is worked off afterwards. Efforts to increase the water supply through blasting with dynamite has not been crowned with success, maybe because the dynamite shots were in beds too deep under the water bearing fissures. 62 pumping it clean with a steam pump, it should give a good water. Temperature 7° to 8°.

4. Dalbyo; south of Hallsviken. Well hole diameter 64 mm; its depth 35 m. Diorite and hornblende gneiss. The water conveying fissure lay at 32 m deep. Wells that for long gave a weakly yellowish, somewhat salty water and a perceptible oil film, are now colorless, crystal clear, the best drinking water man himself can wish. Temperature 7.5°-7.8°.

5. Ryby yard south of Linkoping. Here they had previously blasted a 23.3 m deep well in gneiss, which still did not give any water. From its bottom a 64 mm drill head was first bored to 24.3 m and thereafter 6.5 m with a

drill head of 35 mm. At 7 m below the 64 mm well bottom, thus at a depth of 31.3 m under the rock surface, we hit the water. It. was a good water, but only 1,675 liters per day. It is utilized with advantage for the washing of butter by a creamery.

6. Stockholm, Aktiebolaget Separators gard a Kungsholmen. We attempted drilling from the bottom of a 27 m deep well in Stockholm granite. At 8.5 m drill depth we intersected a water conveying fissure, that gives 15,000 liters per 24 hours. There was a question about making use of the water for feeding a steam engine, but it was said to be calciferous.

7. Trollhattan I. Rocks consisting of gneiss with pegmatite courses, varying with hornblende schist. Well hole 39.7 m. The water bearing fissure encountered within the depth attained. Diameter 64 mm. Ample, crystal clear, palatable water, containing 35 parts solids in 100,000. Temperature +8°.

8. Smogen on an island in Bohuslans Archipelego. Rocks consisting of a regularly vertical lifted red granite. The well hole opening located 5 m above sea level. The water conveying fissure found at a depth of 35.4 m. At that depth down fissure intersects with fissure. Fissures conveying water less liberally had been found at 10.5, 14 and 19 m deep. The water supply is ample, but the water is, as yet, a little salty.

9. Marstrand. The well opening located 8 m above sea level. The well was bored to a depth of 44 m in mica rich gneiss, the water conveying fissure encountered handsomely as before. The supply of water 600 liters per hour. The water first-rate good. The water in the well rises to 3.5 m from the rock's rim.

10. Stenungso near coast of Bohuslan. The rocks are principally gneiss. The well hole mouth 10 m above sea level, about 25 m from the sea-beach. Depth 45 m. The well hole sunk, in the usual manner, considerably below the water conveying fissure. The supply of water is not particularly ample (60 liters per hour). But the water, firstrate good, is perfectly salt free.

11. Koon midst to Marstrand. The same rocks that are near Marstrand. The well sunk to a depth of 50 m, but the quantity of water from it is not worth mentioning, the usual horizontal fissure, which here is very thick, is entirely clay filled.

12. Trollhattan n. In the pharmacist's cellar. The water of the same quality and about the same quantity that was obtained in drilling Trollhattan I. The well depth 36 m. Diameter 64 mm.

13. Trollhattan III. Situated only about 12 m from Trollhattan No. II. The well like Trollhattan II. The water is withdrawn here by means of a little steam engine. It delivers water of the same quantity and of the same fresh quality as that of the two previously cited wells at Trollhattan.

14. Hango. The well hole 49 m. Diameter 64 mm. The water conveying fissure encountered as usual at about 32 m. The well produces at least 500 liters per hour. In the beginning the water was strongly befouled with borings, oil from the drilling machine and pump rinsing-water. But the well has, after repeated running and draw pumping during its intense use in the summer drought of 1896, considerably improved. The water proved entirely clean, in short, perfectly good. The water quantity at least 1000 liters per hour. Temperature +6.9°.

15. Stockholm; Vinterviken. The rocks are principally gneiss. The well hole was sunk considerably below the water bearing fissure, which was encountered at the usual depth. A shot of 3 kg dynamite was let off below, with the previous very ample amount of water increasing. The water is good, but was colored with fissure clay for a long time.

16. Dannemora: Haglosa. The drilling began from the bottom of a 4.5 m deep well and continued to a well depth of 21.3 m. Diameter 64 mm. The rocks—petrosilex (hornstone). Rich with water, that in the beginning was, as usual, fouled with clay and borings. After pump cleaning, the water improved considerably and remained sufficiently up to standard.

20. 35.5 and 36.5 m for obtaining water for manufacturing purposes are here drilled in granite gneiss. Diameter 64 mm. The amount of water was inadequate for manufacturing purposes, but why give up the wells without properly pump cleaning? The owners have unnecessarily become frightened by an analysis, that gave 85 parts solid constituents, thereof 17 parts chlorine per 100,000. By continued pumping on account of this problem, in and of itself not a little forbidding, the residual would be reduced considerably. The chlorine is, of course, combined with sodium as sodium chloride. The taste imperceptible, the quantity of this element is not in the slightest degree injurious to health.

21. Bokedalen near Goteborg. From a 64 mm well hole, sunk to depth of 30 m in gneiss, an ample supply of water is received. The water flows over the well opening. It is slightly irony. The per cent of iron was still

gradually reducing and the water should later on remain perfectly good.

21. Hufvudskar in Ostersjon. Drilled in gneiss to a depth of 53 m, still without increasing the quantity of water that was obtained at about 32 m deep. This is only 60 liters per hour, but should gradually increase. Even now the water is still completely sufficient for the pilot station's needs and perfectly good.

22. Gellivare. The well gives ample water, even with the accessible pump and not the customer's bilge-pump. Here is obtained up to 40 liters per minute, corresponding to 2,400 liters per hour. The temperature after several hours' pumping is +3.1°. The water is pure and clear and without taste. Depth 40 m. Diameter 64 mm.

23. Katrinefors nara Mariestad. The drilling, done for manufacturing purposes, to a depth of 30 m from the bottom of a 6.5 m deep well in primary rock. Diameter 64 mm. Gave 600 to 700 liters water per hour. It was clear and had a temperature of 7°. The amount of water was not enough for manufacturing, for which reason the well hole is not seen used.

24. Stockholm; Liljeholmens stearin manufacturing. The well hole has a diameter of 100 mm. Depth 37 m. It was sunk in Stockholm granite. The supply of water is at least 1,200 liters per hour, without diminution after 12 hours pumping. Temperature 7°. The water is first-rate good. 65 25. Stockholm; Sodra yeast manufacturing. The well hole was like the former (no. 24), 100 mm in section. It was sunk in Stockholm granite to a depth of 31.5 m. The water supply is extremely ample. The well gives 3 to 4,000 liters per hour under uninterrupted steam pumping for 24 hours. The temperature, after the water went through a long lead above the earth, 8.7°, probably originally 7° to 7.5°. The water is first-rate good and palatable, if even a little hard.

26. Oregrund. The well hole's diameter 64 mm. Depth 29 m The rock, gneiss. The water supply is ample. In the beginning there were moans over it, that the water had a salty taste, was yellowish and covered with an oil film on its surface. It is already much improved, so that it is used for drinking water, and it is entirely certain to remain perfectly good for some time. The temperature ranges to 8.5°, but was probably a little lower.

27. Stockholm, Skonvik. Drilled through the medium of a percussion drill in gneiss. Diameter 64 mm. Depth 30 m. It has provided an ample supply of good water.

28. Kungsholms fortress outside Kariskrona. The well hole's diameter 64 mm. Ample supply of water. At this writing, the drilled well has as yet not been pumped clean, so that a definitive opinion on the water's condition can not yet be given. (c)* The well hole was sunk to a depth of 31 m. in gneiss.

In all of these well holes, with the exception of no. 11 Koon, (d)* water has been obtained sufficiently satisfactorily, generally in ample quantity, by which I mean a water supply of 600 to 1,000 and all the way up to 3,000 liters per hour. The water quantity increases perceptibly, after the wells are used for a time, whereby the opening of a new vein in the rock's interior is usually, for a short time, accompanied with renewed dirtying of the water by an extremely fine clay mud. The water that is found is in the beginning substantially dirtied by boring mud, by oil from the drilling machine and the pumps put

*(c) After the above was written, three additional drilled wells have been completed, namely 29 Haparanda, 30 Trollhattan IV and 31 Svenska Hogarna: as far as I know, with good results.

*(d)The horizontal fissure, that usually contains water, is greater at Koon than at other places where drilling has heretofore been undertaken, but it is completely stopped by clay. One has hopes that this clay damming can be worked off through persevering bilge-pumping, in which case even this well will come to supply ample water. 66 into it and also generally of a little clean water, that under drilling and with the turbulence of the pumping in the well hole carries away the boring mud. To this must be added the mud from the water bearing fissures in the rock. An extremely large quantity is added by pumping the water below the drilling; after the well hole is at greater depth, not more returns up immediately, but is distributed in the rock's fissure system; there it mixes with the water in the horizontal fissure and only slowly is brought off. If, as it often happens, sea water is used for washing and priming the pump continual pumping removes all trace of it. This gives cause for illegitimate complaints about the water coming out of a new well. Soon, after the pump is installed, a man complains that the water is unfit. "Oil film deposits on the water's surface, the water tastes of oil, is salty and mixed with clay." It usually stays a long time, but this difficulty is completely conquered, for within the water is crystal clear, palatable, and specially suitable for drinking water, even though a little hard for certain domestic needs—a disadvantage that is nevertheless in rich measure counter-balanced by the water's hygienic quality. It is, to be sure, free from organisms injurious to health and free from organic detritus.

According to tests that have been made up till now, the water pours from these wells 20 to 62 parts solid constituents of 100,000. Until now only one little nearly complete analysis has been made of the composition of the mineral constituents that comes in the water, namely that of the assistant G. Lindstrom on the residue after evaporating the water fetched up on 25 March 1895 from the well hole at Dalbyo. These were the contents of 100,000 parts water:

Silicic Acid 1.18
Clay, ferric oxide 0.10
CaO 4.90
Magnesia trace (?)
Sodium oxide 24.52
Potash 1.70
Chlorine 11.34
Sulphuric Acid 10.42
Carbonic Acid 7.30
61.46

or:

Silicic Acid 1.18
Clay, ferric oxide 0.10
Sodium chloride 18.70
Sodium carbonate (e)* 22.32
Calcium sulphate 11.10
Sodium sulphate 3.52
Potassium sulphate 3.14
60.06

Water from No, 20, Bokedalen, sample taken a short time after the drilling was finished, from within the hole according to an investigation made in Goteborg; the constituent parts per 100,000, after drying up 28.8, after heating to red hot 22.80. Acid consumption 0.22. Ferric oxide (with clay?) 0.10. No ammonia, nitric acid or nitrogen trioxide. Only a slight trace of chlorine and sulphuric acid.

Water from No. 2, Saltsjobaden, taken shortly after the drilling was finished, according to a first-rate test by Stockholm's Water Works laboratory; the evaporated residue (per 100,000) 44.3. Acid consumption 0.193. Neither nitrate nor nitrite. Ammonia 0.002. Chlorine 12.0. Hardness 6.9.

Any complete analysis has not yet been made. In many of the drilled wells the water previously freed has scarcely yet obtained its normal composition. The contamination lingers for very long, namely, the water is certainly frequently salty and never entirely clean while drilling, putting the pump in and, especially after the horizontal fissure is opened, until the greatest parts which remained spread in the rock's fissure system are so completely removed therefrom, that it does not have influence on the well water's composition. The drilling company has had many difficulties, before it became attentive to these circumstances and as a consequence of this gave its work order for the removal of the borings that makes, in this way, clean water possible. So inadequate are analyses that those made show in all cases, that the water corresponds in its composition to a good spring water, perhaps still with the difference that the water in the drilled wells, sunk in the archipelago rocks surrounded by the sea, contains more sodium chloride and sodium carbonate than the usual spring water. When the water channel stands in a heated place, the water pumped out evolves no slight amount of gases. It would be interesting to know the composition of these gases, but the determination thereof has as yet not been arrived at. Then the mineral, Cleveite, in which Helium is especially found, which is by no means a mineral crystallized out from a molten magma for it doesn't even contain quartz, feldspar, mica, etc., is crystallized in fissures of primary rock. It is newly formed at present under prevailing geological conditions, so it would be particularly interesting to have an analysis of the gases in the fissure water of primary rocks, and I shall use the first occasion to have such an investigation performed. Then, I hope also to be able to communicate complete analysis of the additional composition, quite certainly varying in the water from a number of dissimilar wells drilled in the primary rock. Then, after this, the meaning of the movement in our primary rock of granite, pegmatite and of other mixed silicates ought to be known even slightly by the unprejudiced, the open-minded researchers who are free of scientific dogma; equally as valuable are the movements of calcite, pyrite, etc., formed and continually forming through crystallization from the water, which in the manner I now point out, circulates everywhere in the primary rock's fissure system (f)*, so a series of similar analyses ought to prove of extremely great geognostical interest. They ought to make certain that the first attempts are made after the wells are in use for a long time, so that one can be fully confident about the fact that the boring water pumped into the borehole (and fissure system) was completely removed.

*(e) It is very likely that bicarbonate enters into the water. Soon after being pumped up the water is neutral, but after boiling down to half the volume reacts weakly alkaline.

Sixteen of the above-mentioned bore-holes, namely No. 1 Arko, 2 Saltsjobaden, 3 Tacka udden, 4 Dalbyo, 8

Smogen, 9 Marstrand, 10 Stenungso, 11 Koon, 14 Hango, 17, 18, 19 Tolkis Holme, 21 Hufvudskar, 26 Oregrund, 27 Skonvik, 28 Kungsholms fortress, were sunk in rocks located immediately near the sea beaches or on islands in the archipelago. The water they have given, with a mere trace of no consequence, exists free of sea salt, with the exception of the water from No. 8 Smogen. Yet each well amply productive gave a water that was a little salty. An enormous body of sea water had been pumped in while drilling, and I take it that the complained of saltiness is due only thereupon, that the wells have still not been pumped clean. It must still be agreed that the rock here is very full of fissures and that the wells therein became stocked too near a sand-filled depression that yet within the memory of man was filled with stagnating sea water.

*(f)I point out, that with reason, I was confounded for a long time after I had been shown that quartz and feldspar occur as newly formed in fissures in pegmatite dikes. Near Morefjar near Arendal, I have found at the entrance to a similar stuffed fissure, so newly formed that the fragment of feldspar had still not weathered, that through crystallizing out quartz, as if glued together, formed surfaces of great size; that at a lateral fissure near a clear surface, loose quartz crystals formed; that new forming of garnet, diopside, epidote, apatite, titanite, magnetite, calcite, chlorite, galenite, occur as pretty loose crystals in a clay like that of the foliated lamina formed mass that filled the Tabergs mine in Vermland.

No one has taken measurements of the water's temperature at the bottom of the wells. The pumped up well water has a temperature that in unlike wells vary between 7° and 9° and that is constant in each well the year around, apart from all regard of the influence exerted by the season's varying temperatures in the 20 to 30m long pump pipe. The water's temperature was 2° to 4° higher than the place's average temperature. In consequence of the slight depth of the wells, does not this behavior depend on the interior earth temperatures? It appears to depend on a slight heat production by the endless chemical alterations that take place even in primary rocks . I need not bother to point out that a temperature of 7° to 9° is especially suitable for the water that is used for drinking water and other household needs. It is healthily cool in the summer and drinkable directly even in the winter.

It appears from the above, that everywhere that one drills in the primary rock in Sweden and Finland, at a constant depth of a little over 30m under the surface of the earth, a water bearing horizontal fissure is encountered. The theories about folding and the displacement of the primary rocks' surface layers by temperature variation have been clearly corroborated hereby.

Even in lands other than Scandinavian and even in hard species of rocks other than the primary rock, the identical causes ought to have the identical effects. Everywhere that the surface layers are made of hard, firm rock, it appears to me that a displacement of the surface layers ought to take place through folding brought about by daily, yearly, or secular temperature variations. Having been 70 folded, these almost parallel displacement fissures ought to emerge at a greater or lesser depth under the earth's surface. Even though the species of rocks themselves are impermeable to water, and even though atmospheric precipitation doesn't take place in the region or the fissure system does not connect with water collecting on the earth's surface, one ought to question the manner in which the water is received, presumably at the same quantity that was obtained by ourselves, i.e., as a rule not fountains, but wells, that through a little heavy pumping delivers 500 to 2,000 liters per hour. One ought in this manner to get productive water wells around the year, e.g., in many parts of Africa's north coast, in rocks round the Nile delta, in Abyssinia, in south Africa, in appropriate places of the Mediterranean's north coast, on Spain's high plateau, near the base of Sinai and of other snow-covered or heavily rained mountains, in Greece and the whole of Asia Minor and in vicinities where for the whole or greater parts of the year there are dried river beds, in Colorado's Canyons, in tropics that are dry in certain times of the year and rain-drenched at other times. One such water well will be sufficient for household needs in smaller communities, for irrigating a garden, and so on, but not for vast cultivating enterprises. In most of them the water comes in the same condition as that of good spring water. It comes free from the bacteria that exist in the earth's surface layers, from organic detritus, from decay produced and other things injurious to health and for our purposes it is unexcelled in hygienic respects, having a temperature transcending a little the average temperature at the place where the wells were drilled.