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Availability of Primary or Juvenile Water for Ordinary Uses

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Progressive depletion of the water supplies of many of the desert valleys of the Southwest, both because of recurrent droughts and because of overdevelopment, has focused increasing attention on the possibilities of developing supplementary water supplies from sources that are immune to drought, or at least whose development will not interfere with an existing supply now being utilized. Among the possibilities that are the subject of research by scientific organizations and other agencies are conversion of sea water and other saline water, salvage of water now used by phreatophytes (water-loving plants) of low economic value, and induced precipitation (rain-making).

Considerable interest has developed also in the possibility of locating primary water - that is, water that has originated deep within the earth and is rising toward the surface for the first time.[1] If such water is available in substantial quantities at moderate cost, and if its quality is such that it is usable for ordinary purposes such as domestic, irrigation, and industrial, techniques for locating and developing it would be of great potential importance in water-short areas throughout the Nation and particularly in the arid Southwest. On the other hand, if water purported to be primary should prove to be

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[1] Revolution in water-seeking, Part I: Fortnight, v. 15, no. 5, p. 10-12, Aug. 31, 1953; Part II, v. 15, no. 6, p. 18-19, Sept. 14, 1953.

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of meteoric origin (derived from rain and snow), then its development would have to be considered in relation to that of other water of meteoric origin in the same hydrologic basin; and its use would be competitive with other uses to the extent that its development did not salvage water otherwise running to waste. It is the purpose of this memorandum, therefore, to evaluate, so far as can be done on the basis of existing information, the possibility that primary water in usable quantities and of usable quality is available for development.

Primary or, as it is better known in geologic literature, juvenile water exists deep within the earth, combined with or dissolved in the rocks under great heat and pressure. Its existence is demonstrated by the fact, among many others, that every volcano in erupting gives off large quantities of water vapor, together with other gases, even in dry-land areas where the rocks of the earth's crust have such small porosity that they could not conceivably contain enough water from precipitation (meteoric water) to be the source of all the water observed to be emanating from the volcano. It is widely held that additions of juvenile water to the atmosphere from volcanoes and other igneous sources, over the hundreds of millions of years of geologic time, are responsible for the water now present on the earth's surface and in the atmosphere. Another principal theory holds that approximately the amount of water now present on the earth and in the atmosphere was present at a very early stage in the earth's history, and that subsequent additions of juvenile water have increased the total very little percentagewise or have been approximately balanced by water removed from the available supply by combination with newly deposited minerals - for example, gypsum.

The various theories of the origin of the water of the earth's hydrosphere and atmosphere were summarized and discussed by W. W. Rubey/ in his presidential address to the Geological Society of America in 1950. His paper contains an extensive bibliography.

At present we are concerned not so much with the existence of juvenile water as with its availability in adequate quantities and of suitable quality for ordinary uses. There is little evidence as to the quantity available because of the uncertainty as to the degree to which juvenile water has been mixed with meteoric water before emerging at the surface or entering wells, and thus as to the amount and proportion of juvenile water present. The writers, however, have never seen a reference in the scientific literature to any locality where water that was believed to be entirely or essentially juvenile was present in liquid form in any large volume, comparable to the volume present in major fresh-water aquifers in which the water is known to be of meteoric origin.

With regard to quality the evidence is much clearer. Wherever water that can be assumed with confidence to be wholly or essentially juvenile has been collected for analysis (as in the form of vapor escaping from a volcano) it has been found to be so high in dissolved mineral constituents as to be entirely useless for ordinary purposes, and in many cases highly corrosive. In many areas of current or recent volcanic activity, such as the Yellowstone National Park, juvenile water undoubtedly is escaping from hot rocks at depth and mixing with meteoric water, inasmuch as the water from hot springs and geysers, though much more dilute than typical juvenile water, has a chemical content more characteristic of juvenile water than of meteoric water./ Even such relatively

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/ Rubey, W. W., Geologic history of sea water: An attempt to state the problem: Geol. Soc. America Bull., v. 62, no. 9, p. 1111-1148, September 1951.

/ Clarke, F. W., The data of geochemistry: U. S. Geol. Survey Bull. 770, p. 181-217, 261-292, 1924.

dilute waters that are recognizable as containing some juvenile water typically are too highly mineralized for ordinary uses.

That juvenile water should be highly mineralized is inevitable. Water is the universal solvent, capable of dissolving more different substances in larger quantities than any other. Reference to any textbook of chemistry shows, also, that water that is hot and under high pressure dissolves larger quantities of most substances than does cool water under atmospheric or lower pressure.

At depth in the earth the temperature and pressure are high. In most places the temperature increases from the surface down at a rate of 1 degree Fahrenheit for each 50 to 100 feet of increased depth. In areas of recent igneous activity this "thermal gradient," of course, is steeper. The pressure increases downward at least as rapidly as it would in a deep body of water, or at the rate of 1 pound per square inch for each 2.3 feet of increased depth. At great depth, where openings in the rocks do not exist, the pressure is equivalent to more than 1 pound per square inch per foot of depth beneath the surface.

Thus, juvenile water inevitably must dissolve large quantities of the chemical constituents making up the rocks. As the water rises toward the earth's surface and cools, the less soluble constituents like silica largely separate out, but even if the water cools to or nearly to atmospheric temperature as it comes near the surface it still contains large quantities of the more soluble constituents like sodium and chloride.

It is concluded, therefore, that true juvenile water may be expected to be highly mineralized under any and all circumstances. In any place where the proportions of the chemical constituents indicate juvenile rather than meteoric origin, if the water is dilute enough for ordinary uses it must have been mixed with meteoric water. Therefore, it cannot be considered to constitute an independent source that is immune to drought, nor can it be developed without regard to the effect of the development on other fresh-water supplies in the same basin.