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PRELIMINARY REPORT ON SUGGESTED SEISMIC STUDIES AND DEEP WATER WELL TESTS

by

WARD H. AUSTIN
President
ICON Resources, Ltd.

Registered Geologist
State of California
License No. 001086

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CONCLUSIONS AND RECOMMENDATIONS

1) Numerous fault/fracture zones are annotated on aerial photos of the Indian Wells Valley. This, combined with the knowledge of similar fault fracture patterns found on a study for another client in the Coso geothermal area, suggest many fault/fracture conduits which may allow Sierra Nevada Mountain water to flow into Indian Wells Valley. The numerous fault/fracture zones may equally allow deep water flow out of Indian Wells Valley into Searles Valley.

2) The magnitude of the potential waterflow into Indian Wells Valley is suggested by the results at the Coso Geothermal field. Seven wells on extended test indicate a potential flow of over 8000 acre feet per year out of one 2400 ft. diameter fractured granite reservoir. The long term water flow for the geothermal field has been estimated as at least 69,000 acre feet per year for a 12 square mile area.

3) Since the fault/fracture patterns between the Sierra Nevada Mountains and Indian Wells Valley are similar to those seen in the Sierra Nevada Mountains, Rose Valley and Coso Geothermal Field (excluding the obvious igneous intrusion fault/fractures) it is suggested that the water flow into, across, and out of both areas will be similar.

4) Shallow well water analysis in Indian Wells Valley indicates that if the shallow analysis is considered, the best area to drill water wells with good quality water is south of an E-W line through section 36, T 25 S, R 39 E, and west of a N-S line through sec. 21, T 27 S, R 39 E.

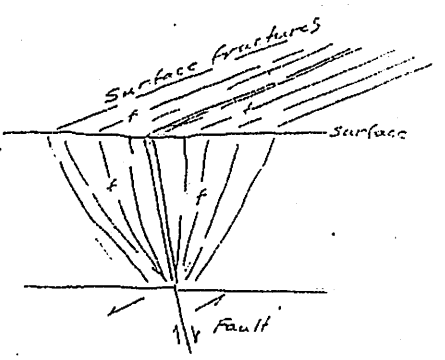
5) Contrary to prior predictions by some, the water quality in the Navy 1015 ft. well near the junction of highways 395 and 178, improved in quality with depth. It seems possible that this may be the rule instead of the exception throughout Indian Wells Valley except in areas where wells tap either geothermal brines and/or isolated lenses of highly saline lake brines. The DOE Rose Valley 4000 ft. test is an excellent example of finding good water under a thick impermeable lake clay section. Only a program of selected deep water tests will give the answer.

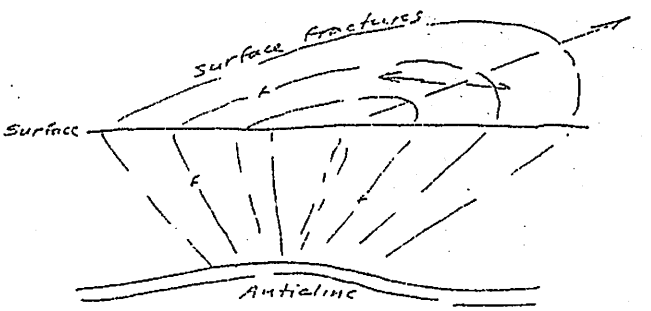
6) COMAP has recommended three non-linear vibroseis lines which will detail the subsurface structure and give some indications of the possible stratigraphy in Indian Wells Valley. These include a NW-SE line (1) through Freeman Junction which intersects a N-S Line (2) on Jack's Ranch-Snort Bypass roads which in turn intersects an E-W line from Sand Canyon across Indian Wells Valley to the Argus Range. A fourth line is suggested which might have interest for Kerr McGee running from Jack's Ranch Road through Salt Wells Valley into Searles Valley.

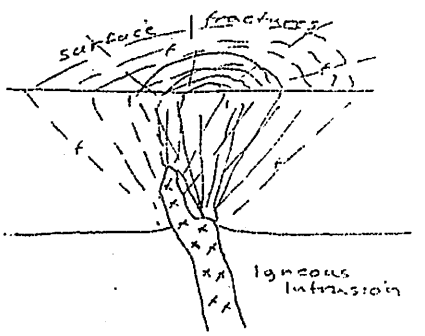
7) A total of 6 potential deep well locations are suggested of which the first two, adjacent to the Sierra Nevada front, will probably be excellent producing water wells. All the suggested locations are located in good apparent fault/fracture zones at sites which will help control the proposed seismic studies. Wells east of the Sierra front may have water quality problems but it is suggested that the deep underflow water may be of high quality as long as localized geothermal fluids can be avoided.

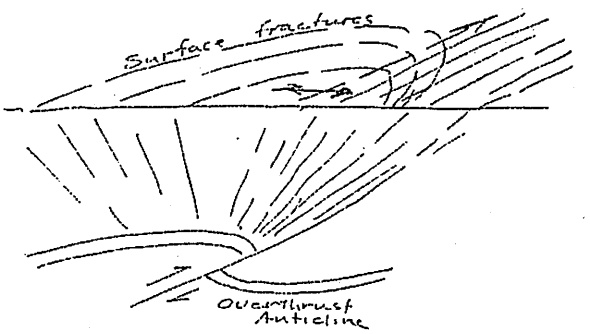
Aerial photo fault/fracture studies rely on the fact that when rocks crack, the cracks fill with water and surface plants which have roots in the moisture filled cracks or in the soil over these cracks will grow leaves with a brighter color than plants not growing in cracks. The brighter colors form distinct patterns on aerial photos.

Fault fracture zones are often nearly straight and often traced continuously for many miles. Linears or lineaments are commonly used by geologists in deciphering the geological structural history of an area. Straight line linears are easily recognized by most geologists and can be computer analyzed as they have a midpoint, two ends and a bearing (N-E or N-W). Curvilinear fracture patterns are as numerous as linears but up until recently were difficult for most geologists and many photo annotators to recognize and utilize. All fault/fractures, unless sealed by plastic non-permeable material, will tend to be kept open by earth movements which include the twice daily earth tides which raise and lower the earth's surface 12" to 18" in a rolling motion.

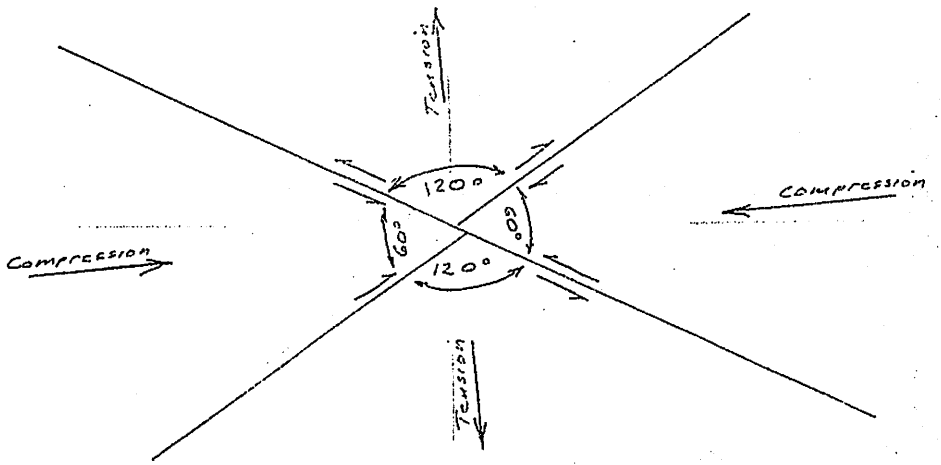








Most photos studies in Indian Wells Valley have numerous groups of fault/fractures superimposed on each other, complicating the interpretation. A simplified interpretation shows that fault/fractures that intersect at about a 60 degree angle as shown in the diagram below are complementary fault/fractures. These are often seen to have relative displacement in the direction shown by the arrows on the following diagram.



It is noted that in the Eastern Sierra Nevada Mountains, Rose Valley, Indian Wells Valley, the Coso area and Argus Range, that the patterns showing E-W compression dominate both the aerial photo studies and the COMAP aeromagnetic studies. It is interpreted that these patterns have been formed by eastward thrusting of the Sierra Nevada Mountains which the recent COMAP gravity/magnetic studies indicate have at least a 7 km (4.2 miles) of Sierran granite thrust over the Western Indian Wells Valley sediments. Note that overthrusting may be significantly greater but while a granite thrust plate overlying sediments is relatively easy to interpret the case of a highly fractured granite plate on top of a highly fractured granite plate is much more difficult to delineate geophysically.

The importance of fault/fractures in the Indian Wells Valley area is both as a conduit and as a reservoir. There has been much discussion of sand and gravel as an aquifer capable of storing and acting as a conduit for water. Persons not familiar with water problems in a mining district assume that igneous and metamorphic rocks are impermeable and incapable of forming reservoirs. Mining experience shows that brittle, easily fractured rocks, such as granite, may form excellent reservoirs and conduits for the sotrage and movement of water.

At the Coso Geothermal Field it now appears that the sustained fluid flow from seven wells in one breccia pipe reservoir (granite breccia in a granite host) is currently equal to over 8000 acre feet per year water flow. If this flow rate is sustained over the next 24 years or longer as predicted, it indicates that an enormous quantity of water is flowing in and through the Coso area with no significant expression at the surface prior to drilling the steam wells. Again, it is interesting to note that the reservoir is brecciated granite which many people say is impermeable and not a water reservoir. It is very important in evaluating the water supply of Indian Wells Valley to remember that Dr. Fournier of the USGS, Menlo Park, California has reported that his studies indicate that water from the South Fork of the Kern River West of the Sierra crest is going down through the fractured granites of the Sierra Nevada Mountains, under the Rose Valley and then at least some of the Sierran water is being heated and driven close to the surface (3500 ft. $\pm$) at Coso where it is being tapped in steam wells.

Where did all of that water go before its presence was proven by development at Coso ? It is probable that underground water flow in fractured granites is going East and Southeast toward Searles Valley and toward Indian Wells Valley. Estimates of the minimum potential production at Coso are currently 1000 MWe and greater. Note that 1,000 MWe requires a water flow or recharge for sustained production of about 69,000 acre feet per year. Since the Coso area is not currently thought to be unique in the amount of water flowing from the Sierra Nevada Mountains through the geothermal field area, the next question is what is the flow through Indian Wells Valley ?

The shallow well data indicates that there are at least seven different kinds of water in Indian Wells Valley. These are listed as follows:

1) Typical Sierra Nevada near-surface water.
2) Modified Sierra Nevada/Western Valley water.
3) Modified Coso Geothermal water flowing south from Little Lake.
4) Steam Cap Water (Geothermal) SW Indian Wells Valley.
5) Geothermal Water (high silica, high arsenic) SW of Ridgecrest.
6) East Airport Lake brines (50,000 ppm boron!)
7) Arsenic rich water East of Ridgecrest near the San Bernardino County line in an area of abnormally high ground temperature.

It is expected that other water type modifications will become apparent as all 312 analyses completed to date become available. Most of the water wells in Indian Wells Valley

are around 400 feet or less in depth. The only exceptions are the 1015 ft. Navy well in the SW NW 29, T 26 S, R 39 E, and the 1000 ft. Kerr McGee well in SE SW sec. 8, T 26 S, R 39 E R 39 E. Note that in the 1015 ft. Navy well, water quality improved with depth. The only really deep test in the area is the Rose Valley DOE NURE test which found good water at 4000 feet below a 3700 foot clay lens.

The aerial photo fault/fracture studies backed by gravity/ magnetic studies appear to have shown large numbers of fault/ fractures. The structural interpretation of these fault/ fractures suggests that Indian Wells Valley, like the Rose Valley/Coso area, is an open basin with very large quantities of water moving into and out of the basin. It should be noted that until several deep water wells (4000 ft. or more) are drilled in carefully selected portions of Indian Wells Valley there can only be speculation on how open or closed the Indian Wells Valley Basin may be. For the future growth of the Valley or even maintenance of the current development, it is going to be important to determine both the quantity and quality of the water that may be available. It is of no importance to people in the Valley what direction various faults moved, or if the area is under compression or tension. What is important is the prevalence of numerous faults and fractures. In most of the area where good photo detail is available, the fault/fractures show up well at least every 100 feet on 1:24,000 scale photos. On the ground, with good outcrops, fractures can be seen to have a much closer spacing.

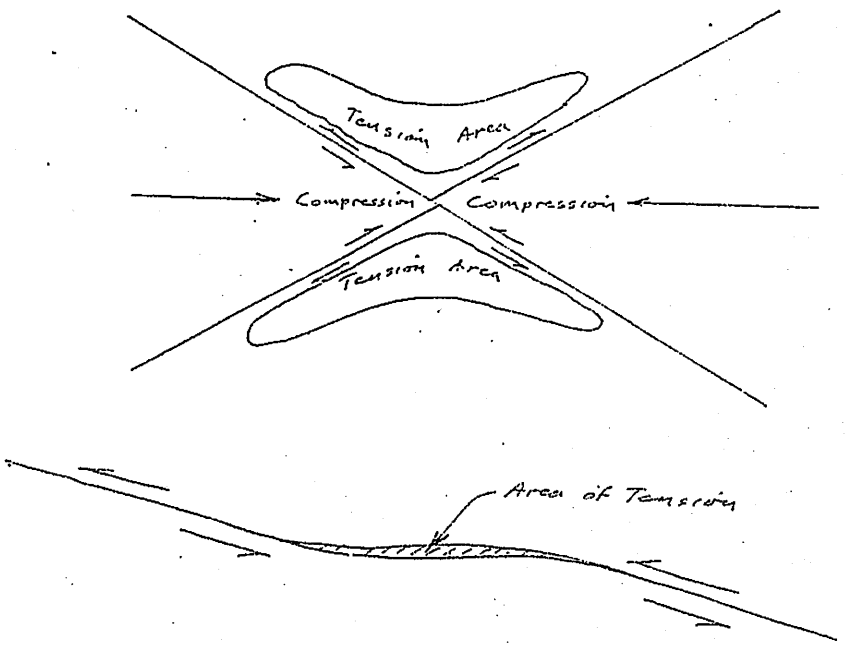
At this stage it is difficult to say how much of the shallow water geochemistry is related to lateral flow and how much to vertical pluming from local geothermal centers. At least six local possible geothermal centers are recognized. Steam cap fluid is found in the area Southwest of Inyokern (steam condensate). and appears associated with a deep steated intrusive. The Airport Lake brines (50,000 ppm boron!) may be related to the White Hills intrusive which is suggested by the COMAP gravity/ magnetic study. Two geothermal centers are suggested by the gravity/magnetic study with one centered north of the China Lake Naval Weapons Center Airfield, and the other East of China Lake west of Lone Butte. The high silica, high arsenic fluids in the area 6 miles southwest of Ridgecrest may well be geothermal and associated with a fifth intrusive and the high arsenic waters east of Ridgecrest associated with a possible sixth geothermal center.

If shallow geochemistry is to be a major criteria, it now appears that deep tests for good water should be located south of section 36, T 25 S, R 39 E and wast of a N-S line through section 21, T 27 S, R 39 E. The best potential would appear to lie along a line from the Kerr McGee 1000 ft. test in SE SW section 8, T 26 S, R 39 E through the Genesis Minerals Tank at Armistead, section 31, T 27 S, R 38 E. The Genesis Minerals Tank quality suggests a geothermal steam cap condensate origin for the water. If the source is directly below there is a danger that quality may deteriorate with depth as geothermal steam probably is formed from the boiling of a deep seated geothermal brine. Only deep drilling will show at what depth there might be a water quality problem. Note that at Coso no geothermal brine has been reached at 6500 feet and it is suspected that the brine will not be encountered until about 11,000 feet in the fractured granitic reservoir.

COMAP has proposed three nonlinear vibroseis seismic reflection lines in the Indian Wells Valley study area. Line 1 would start as far up the Walker Pass road as possible and proceed through Freeman Junction to near the center of section 32, T 27 S, R 40 E. This line would have the maximum chance of showing the true nature of the suspected Sierra Nevada overthrust on the West side of Indian Wells Valley. A non-linear vibroseis profile would give the maximum detail of the stratigraphic section which could later be controlled by drilling deep water wells. It is suspected that the highly fractured "basement" rocks on this line will include Paleozoic meta sediments including limestones as seen in the El Paso Mountains outcrops. Note that vibroseis information gives far more detail than refraction seismic lines and is the type of information used in modern oil and gas studies. Line two would run N-S from the SE corner of section 36, T 27 S, R 39 E along Jack's Ranch road to the NWC boundary and then north along Snort Bypass road ending at the Kern-Inyo County Line. Line 3 would start as far west as possible up Sand Canyon and proceed eastward into the NWC on Brown Road at least as far as the Kern-San Bernardino County Line. It would be best if this line could be extended all the way across Indian Wells Valley to the Argus Range.

If support could be obtained from Kerr McGee, it might be useful to run a fourth seismic line from Jack's Ranch road eastward on the Trona road through Salt Wells Valley into Searles Valley. Such a line along with suitable deep water well tests might aid in showing the potential eastward flow of water out of Indian Wells Valley into Searles Valley.

From a scientific standpoint, it would be useful to have deep wells (4000 to 5000 ft. or deeper) along seismic lines 1, 2 and 3. A review of the fracture patterns annotated to date suggests the following well sites. Well site selection has taken into account the fault/fracture pattern with the idea of drilling in an apparent tension segment of a local pattern.



POTENTIAL VIBROSEIS LINE DEEP STRATIGRAPHIC CONTROL WATER WELLS

1) LOCATION: NE¼ sec. 16, T 27 S, R 38 E

COMMENTS:

On proposed seis Line 1, ½ mile E of Sierra thrust front by COMAP. On the crest of an apparent thrust front fold fracture pattern and on NW trending fault/fracture zone of Freeman Canyon. Should have good water (shallow steam cap condensate ?).
Note that Dr. Whelan's first choice location is the SE sec. 16, T 27 S, R 38 E.

2) LOCATION: NW¼ sec. 2, T 25 S, R 38 E

Preferred location is 3000 feet east of highway 395 and 7000 feet north of Brown Road (seis Line 3). This lies in the Noname Canyon Fault fracture offset on the N. plunge of a Sierra front fold fracture pattern. Shallow water has apparent geothermal component.

Alternate location is on seis Line 3.

3) LOCATION: NW SE sec. 10, T 25 S, R 38 E

On seis Line 3, about 3000 feet E of COMAP Sierra thrust front. Surface water has apparent geothermal component but deep water may have good quality.

4) LOCATION: NE corner SE sec. 12, T 25 S, R 39 E

Junction of Seis Lines 2 and 3. Note apparent geothermal component in Centerline Road well in sec. 11, T 25 S, R 40 E near Kern-San Bernardino line.

The location of tests near the SE end of Line 1 and the south end of Line 2, should await completion of the proposed seismic work. A test sited at the junction of lines 1 and 2 in the SE sec. 25, T 27 S, R 39 E may be too shallow even if drilled into the fractured basement, to be of major interest. Better locations for deep tests might be listed as follows taking into account that there is high arsenic reported in well water east of highway 395 near the center of T 27 S, R 39 E. Two additional deep test sites might be recommended as follows if confirmed by the stratigraphic section suggested in seis lines 1 and 2.

5) LOCATION: NE SE sec. 24, T 27 S, R 39 E

Located on seismic Line 1 in the junction of the NW trending fault/fracture zone down Freeman Canyon and the NE trending fault fracture zone which may be the indication of the right lateral tear fault forming the south end of the Argus Range. Water quality ?

6) LOCATION: SE sec. 12, T 27 S, R 39 E

Located on seis line 2, about 3 miles north of the junction of seismic lines 1 and 2, in an area of favorable fault/fracture intersections. This site is about 3½ miles SW of the center of Ridgecrest. Water quality at depth is uncertain but there is speculation that the deep water flow may be of better quality. The non-linear vibroseis data might suggest the presence or absence of a clay lens as in Rose Valley and the possibility of layered potential aquifers in sediments below the possible clay lens.