mouth of the river (Aguada Bay). The speed of the current is also partly reduced by the opposing wave action in this region. This may lead to considerable deposition of sediment closer to the constriction resulting in the formation of the Aguada and Reis Magos bars. During the flood current similar deposition may take place (although to a lesser degree) upstream of the constriction near Station A due to the divergence of flood current.

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References


Concentration of Gold in Seawater

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Gold in seawater concentrate (20°B) was concentrated by reduction with Cr(II) salt solution. Spectrographic analysis of the reduced mass showed 10×10^-6 g/litre seawater.

Gold and the other trace elements are present in seawater in small quantities that their direct precipitation is not possible. They are required to be concentrated before analysis. Many techniques viz. adsorption, co-crystallization, solvent extraction, chelate resins, etc., have been suggested for the concentration of trace elements; adsorption being the most widely employed for the concentration of gold. The most commonly used adsorbing agents for gold concentration are iron slag, coal, kieselguhr, cellulose and hydrocellulose, pyrites, colloidal ferric hydroxide, etc. Co-precipitation of gold with metallic sulphides has also been suggested. However, these two techniques allow the gold to be associated with large quantities of adsorbing or precipitating agent without in any way affecting the state of gold present in the seawater. Another very effective method of recent origin for the estimation of gold is the neutron activation analysis which requires elaborate equipment.

The only direct approach for the concentration of gold in seawater is by Bardt who reduced the seawater successively or simultaneously with sulphur dioxide and sulphite lye. Tandon and Mehrtra have precipitated the gold quantitatively from a solution of its salt by reducing it with Cr(II) salt solution. This principle has been extended to seawater and gold has been concentrated directly in the metallic form. The reduced mass was subsequently analysed spectrographically. Cr(II) solution (0.1N) was prepared from potassium dichromate (AnalaR). Jones reductor was modified by using a separating funnel connected to the burette with a long tube for discharge at the bottom. Chromium salt solution was kept over reduced amalgamated zinc (AnalaR). Hydrogen atmosphere was maintained in the assembly throughout. Efficient reduction to Cr(II) was indicated by the appearance of a light blue colour for the solution in the reductor.

Seawater samples were collected from the salt works and were used without any further purification. Known volumes of seawater were acidified with hydrochloric acid (pH 0.1) to avoid the formation of basic double salt of chromium by hydrolysis. Dissolved oxygen was then removed from the brine by adding, carefully, 25 ml of 5% solution of sodium sulphite, to avoid the loss of Cr(II) reductant. Reduction was carried out by adding measured volumes of the reducing agent through the burette whose long tip discharged the reductant at least 10-12 cm below the surface of the brine. Slow but continuous stirring was carried out throughout the addition of the reductant since brisk stirring produces bubbles. Haziness appeared almost immediately on the addition of the reducing agent, but with more concentrated brines (20°B) fairly good turbidities were obtained. The developed turbidity showed Brownian movements but did not settle even after a week. After keeping overnight the colloidal mass was digested on a water-bath till the salt begins to just crystallize. Settling salt scavenge the turbidity. It was then filtered through sintered glass crucible under low suction. The precipitate was washed with minimum amount of hot water till all the crystals of salt were washed out. The precipitate was then dried in an oven at 105°C.

The reduced mass thus collected was analysed spectrographically. Amongst the various unidentified and unconfirmed lines in the spectrum, the lines corresponding to gold could clearly be indentified. From the intensity of characteristic gold lines, the gold was estimated at 0.01% in the reduced mass. The gold content in seawater was calculated (Table 1).

#### Table 1 — Gold Precipitation from Seawater

<table>
<thead>
<tr>
<th>Vol. of seawater* litres</th>
<th>Place of sample collection</th>
<th>Cr(II) solution added ml</th>
<th>Ppt. obtained mg g/litre ×10^-6</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>Bhavnagar†</td>
<td>200</td>
<td>120</td>
</tr>
<tr>
<td>2</td>
<td>Bhavnagar</td>
<td>150</td>
<td>92</td>
</tr>
<tr>
<td>2</td>
<td>Ghoga</td>
<td>200</td>
<td>128</td>
</tr>
<tr>
<td>2</td>
<td>Verna</td>
<td>120</td>
<td>10</td>
</tr>
<tr>
<td>2</td>
<td>Okha</td>
<td>200</td>
<td>130</td>
</tr>
<tr>
<td>3</td>
<td>Bhavnagar</td>
<td>300</td>
<td>191</td>
</tr>
<tr>
<td>4</td>
<td>do</td>
<td>350</td>
<td>260</td>
</tr>
</tbody>
</table>

*Density of seawater sample 20°B.
†Density of sample 4°B.

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**Notes:**

*Seawater samples were collected from the salt works and were used without any further purification. Known volumes of seawater were acidified with hydrochloric acid (pH 0.1) to avoid the formation of basic double salt of chromium by hydrolysis. Dissolved oxygen was then removed from the brine by adding, carefully, 25 ml of 5% solution of sodium sulphite, to avoid the loss of Cr(II) reductant. Reduction was carried out by adding measured volumes of the reducing agent through the burette whose long tip discharged the reductant at least 10-12 cm below the surface of the brine. Slow but continuous stirring was carried out throughout the addition of the reductant since brisk stirring produces bubbles. Haziness appeared almost immediately on the addition of the reducing agent, but with more concentrated brines (20°B) fairly good turbidities were obtained. The developed turbidity showed Brownian movements but did not settle even after a week. After keeping overnight the colloidal mass was digested on a water-bath till the salt begins to just crystallize. Settling salt scavenge the turbidity. It was then filtered through sintered glass crucible under low suction. The precipitate was washed with minimum amount of hot water till all the crystals of salt were washed out. The precipitate was then dried in an oven at 105°C.
Bivalent chromium is a powerful reducing agent having the redox potential of 0.41 V for the reaction.

\[ \text{Cr}^{++} \rightarrow \text{Cr}^{+++} + \varepsilon \]

Chromous salt solution reduces the gold in seawater directly to metallic state. Because of its simplicity, this technique may prove a forerunner of the method for extraction of gold from seawater in the days to come.

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References