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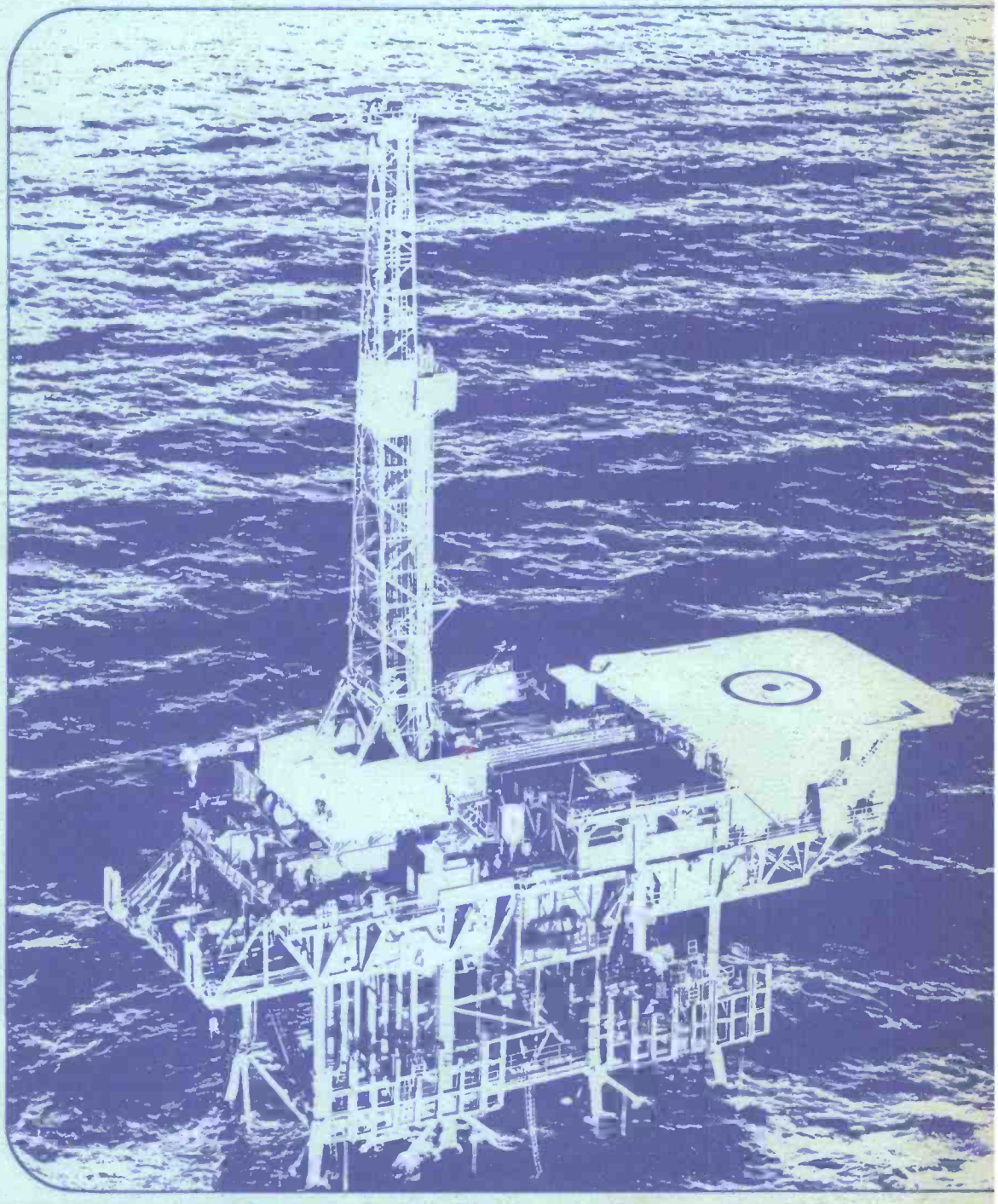

APEA

AUSTRALIAN PETROLEUM EXPLORATION ASSOCIATION

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APEA acknowledges the support and assistance given to the 1976 APEA Conference by members of the Petroleum Exploration Society of Australia by their submission of technical papers for the Conference and the APEA Journal.

pressure decline suggests that the volume of gas in place at the Caroline well is of the order of several hundred BCF.

Table 2. Formation Water Analysis, Caroline No. 1.

	p.p.m.
CO	—
HCO	10784
Cl	1444
SO	174
Ca	37
Mg	8
Na	5830
K	145

(e) Formation Fluids

(i) FORMATION WATER

Table 2 shows the analysis of Formation Water from Caroline No. 1. Estimates of water solubility in carbon dioxide indicate that approximately 0.175% by weight of water must condense in passing from reservoir to wellhead conditions (i.e. 3.3 g/m³ or 205 lb/mmcf, Noyes 1971). Since the Caroline well currently flows at around 2% water by weight, it is inferred that some free water is also produced. The formation water produced is essentially a solution of sodium bicarbonate with minor amounts of chloride and traces of sulphate and calcium.

Table 3. Gas Analysis, Caroline No. 1.

	Liquid Phase	Gas Phase
CO2	98.9% by diff.	
CH4	1.00%	
C2H6	0.013%	
C3H8	0.0049%	
i C4 and n C4	10 ppm	
C5's	20 ppm	
C6's	25 ppm	
C7's and above	present	
He	32 ppm	0.08%
H2	2 ppm	5 ppm
O2	5 ppm	10 ppm
N2	0.10%	0.59%
CO	not detected	20 ppm
H2S	not detected	2 ppm

(ii) CARBON DIOXIDE

Gas analyses at the Caroline and Kalangadoo wells have shown raw gas from the well to contain around 99% carbon dioxide, with the bulk of the residue consisting of light hydrocarbons. Table 3 shows the details of gas composition from Caroline No. 1.

Reservoir temperature and pressure are well above the critical point for carbon dioxide, hence it exists as an indeterminate fluid within the reservoir. The phase change, resulting from temperature and pressure decrease passing up the well column, results in the production of liquid carbon dioxide at wellhead flowing pressure and temperature of 7.1 MPa (1030 PSI) and 28°C (83°F).

The high specific gravity of carbon dioxide (1.515 relative to air 1), compared to natural gases (generally less than 1), means that surface flowing and static pressures for a carbon dioxide well will be considerably less than for a natural gas well of equivalent depth and reservoir pressure. Unique problems also arise during open hole testing of carbon dioxide flows, resulting from the unusual thermodynamic properties of the gas. Natural gas of specific gravity 0.7, for example will have a latent heat of vaporisation of around 120 calories/gm. The latent heat of carbon dioxide is 6030 calories/gm, and dramatic cooling effects occur when the pressure drops, often sufficient for the formation of dry-ice and/or ice in flow lines. In order to overcome this problem a testing string requires a small diameter choke installed at the bottom of the well, so that the pressure drop takes place where the temperature is sufficiently high to prevent icing.

Theoretical pH determinations for formation water under reservoir conditions indicate a pH of around 5. Surprisingly, however, little evidence of corrosion is seen to date at the Caroline well after eight years of production.

PRODUCTION

Raw gas and sales gas production data for Caroline Field are summarised in Figure 8. Production commenced in November 1968 and current annual sales are around 12 000 tonnes (228 mmcf) corresponding to production of 16 500 tonnes (314 mmcf of raw gas). Cumulative production of raw gas to December 1975 is 95 000 tonnes. The maximum production rate achieved to date, given constraints of storage and tanker capacity, is around 79 tonnes (1.5 mmcf/day), raw gas. The seasonal nature of demand also limits total annual production.

Purification of the raw CO_2 is carried out by Carba Australia at their Caroline plant, and shipped to Melbourne and Adelaide by pressurised road tanker. The purification process utilises well-head pressure and involves a relatively simple fractionation system to remove lower boiling point impurities, chiefly methane. Minor H_2S is also present (less than 2 ppm), and is removed by adsorption on zinc oxide.

During the well's production history a period of substantial free water flow resulted in depression of wellhead flowing pressure, but subsequent sealing off of the flow has allowed record production rates from late 1974 onwards.

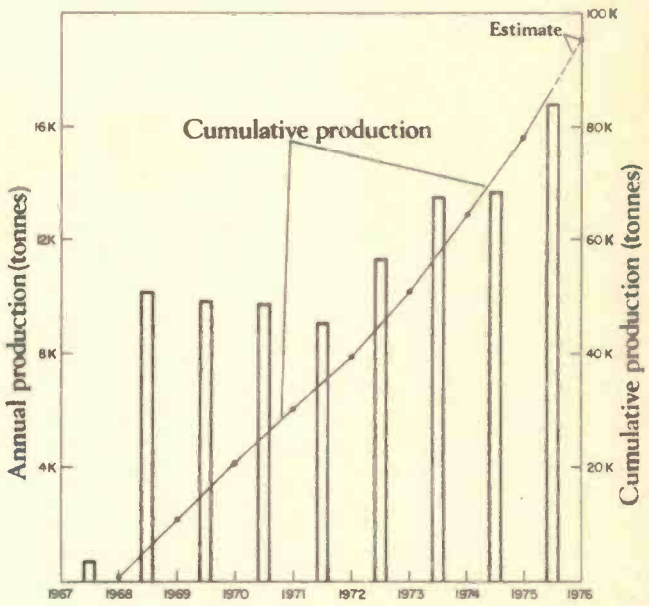

Fig. 8. Production History, Caroline No. 1.

ADDITIONAL OTWAY BASIN CARBON DIOXIDE OCCURRENCES

In the Port Campbell Embayment of the Otway Basin, some 200 km (125 mi) to the east south-east of Caroline No. 1, significant shows of carbon dioxide have been noted by

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