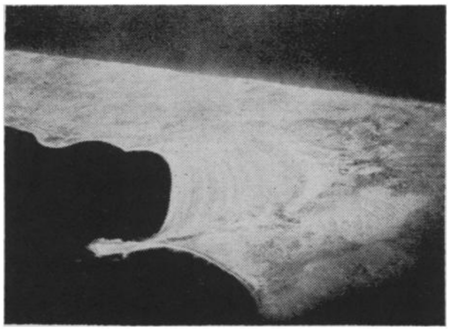

Fig. 1. Elevated beaches along Bahia San Matias in the Valdez Peninsula, Argentina.

tained from the lower terrace deposit. No fossils have been found on the higher terrace.

A shell of *Codakia orbicularis* Linné from the lower terrace deposit on Tierrabomba gave a radiocarbon date of 2850 ± 150 years B.P. (L-719-F). This date indicates Holocene emergence of the region. Uplift is favored as the cause, although a Holocene high stand of only 2.7 m (9 ft) above the present cannot be entirely ruled out. A correlation with the Silver Bluff of Florida cannot be established until the latter deposits are more definitely dated.

Argentina. Darwin (*11*), on his famous voyage of the *Beagle*, first recognized emerged beaches along the coast of Patagonia. While he attributed these to uplift of the land, Zeuner (*12*) and other workers have tried to explain these beaches by eustatic fluctuation of sea level. Feruglio (*13*) described a series of marine terraces up to 140 m (464 ft). He dated the higher terraces from the interglacial stages, while those below 30 m (100 ft) were correlated with the fourth glaciation and postglacial time. Auer (*14*) also found evidence for postglacial high stands of the sea in Patagonia and Tierra del Fuego.

Recent studies conducted by the Lamont Geological Observatory have revealed the presence of a submerged shoreline on the Argentine Shelf at a depth of about 105 m (350 ft). Many of the fossils obtained from cores from this beach indicate a cold, shallow sea, and a correlation with the low stand of the Wisconsin sea is suggested (*15*).

Fig. 2. Pleistocene terraces on Rio Gallegos, Argentina.

Several shells taken in water less than 65 fathoms (119 m, 390 ft) show ages between 11,100 and 17,250 years B.P. and thus suggest a Late Wisconsin age. One sample (L-628) from 82 fathoms (150 m, 492 ft) off Puerto Deseado gave a carbon-14 age of greater than 25,000 years B.P. This may represent a lowering of sea level in Illinoian time (*15*).

In January 1963, shells were collected from various elevated beaches in the vicinity of Comodoro Rivadavia, especially from Feruglio's terrace of that name. A carbon-14 date of *Chione antiqua* King from an outcrop near the electric plant of Y.P.F. (oil company) 5 km north of Comodoro Rivadavia at an elevation of 9 m (30 ft) gave a date of 5350 ± 200 years B.P. (L-740-A).

The finding of an elevated beach only some 5000 years old at an elevation of 9 m at Comodoro Rivadavia casts some doubt on the absolute stability of at least that local region. Recent Argentine workers, notably Bordas (*16*) and Parodiz (*17*) recognize only two Pleistocene marine ingressions along the Argentine coast, and believe that these were primarily due to movements of the land, and that the entire area has been rising and falling epeirogenically since the Pliocene.

While flying over Bahia San Matias en route between Buenos Aires and Comodoro Rivadavia, we noted a series of emerged beaches at Punta Buenos Aires on the Valdez Peninsula. These strongly suggest recent uplift (Fig. 1). Furthermore, the irregular elevation of terraces along Rio Gallegos, 80 km (50 miles) north of the Straits of Magellan, suggests differential uplift caused by epeirogenic movement. Unfortunately, time was not available for detailed field work in that area (see Fig. 2).

Whether the higher terraces along the coast of Patagonia reflect uplift of the land or eustatic changes in sea level is not clear from the available data. Further field work and radiocarbon dating will be necessary to clarify this point (*18*).

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Atmospheric Jet Streams

The earth's high latitude atmospheric jet streams occupy a mean latitude at which the diurnal heat pulse from the sun's radiation moves through the main body of the atmosphere at approximately Mach 1 (speed of sound). At the equator this velocity is approximately Mach 1.4. At latitudes higher than the mean position of the jet stream the heat pulse moves at subsonic velocities.

It is proposed that this is associated with the development of the jet streams by the following mechanism. At the zone of the jet streams (40° to 50°) the cyclic heating must take a form roughly equivalent to a repeating deflagration wave in a gas, with particle flow exhausting mainly in a direction opposite to the direction of motion of the heat pulse (that is, retrograde in respect to the pulse and prograde in respect to the earth's rotation). For a *single* passage the velocity of this flow will be approximately equal to the increased particle velocity of the gas over the temperature rise. Repetitive diurnal events will result in a higher equilibrium velocity and, probably, counterflow. Containment of flow within a zone can be maintained by a pressure discontinuity lateral to the flow.

The several climatic implications of this possible mechanism include a migration of the jet stream to higher latitudes, in the case of a generally cooler or more carbonic atmosphere, and to lower latitudes with a warmer or moister atmosphere. The position is insensitive to moderate changes in the composition of the atmosphere, and to atmospheric pressure.

At the equator, the heat pulse travels through the atmosphere at Mach 1 only at very high altitudes (about 150 km). Direct coupling of this mechanism to the water of the sea is everywhere subsonic and reaches a maximum at the equator, but probably is insignificant even there.

A simple toroidal model has been constructed, which demonstrates the existence of streaming flow in a gas (CO_2) associated with a repetitive radiative pulse from an external source moving circumferentially through the gas at velocities of the order of Mach 1.

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Chemistry and Petrology of Venus: Preliminary Deductions

Abstract. *Recent measurements of the temperature of Venus suggest that a chemical interaction between the atmosphere and lithosphere may occur: the possible consequences of such interaction are examined. Results indicate that metallic iron, free carbon, and magnesium carbonates should not occur on the surface of Venus. Calcium carbonate, iron oxides and certain hydrous silicates may be present, but other hydrous silicates seem to be excluded. The effects of the physicochemical conditions on rock types and the various planetary processes are discussed.*

The relatively high temperatures (400° to 570°K) obtained during the flight of Mariner II (*1*) from microwave measurements of deep atmospheric layers indicate that the temperature of the surface rocks might be about 700°K (*2*). This temperature corresponds with those attained during moderately high degrees of metamorphism on Earth. It is therefore possible that large parts of the atmosphere of Venus are partially equilibrated with the surface rocks. From this assumption, it follows that the composition of the atmosphere should reflect the mineralogic character of the rocks.

The mass and density of Venus do not differ greatly from the corresponding values for Earth (*3*). It thus seems reasonable that planetary evolution has led to surface rocks on Venus which have representatives among the common types of terrestrial rock. For example, we should expect outpourings of both basic and acidic lavas and the corresponding shallow and deep-seated intrusives. However, there should also be significant differences which are related to the higher temperatures and the atmospheric chemistry of Venus. These differences should be most pronounced in the characteristics of the secondary rock types derived by sedimentation and metamorphism, although certain differences in igneous rocks should also occur.

One of the most important parameters is the oxidation state of the atmosphere as revealed by the ratio of the fugacities or partial pressures of carbon dioxide and carbon monoxide (pCO_2 to pCO). Spectroscopic data for Venus indicate that the lower limit for the ratio pCO_2 to pCO is about 10^3, with no detectable carbon monoxide (*3*). However, a small amount of CO may have been detected recently (*4*). Also, the spectra indicate that pCO_2 is approximately equal to 10 atmospheres (*2, 3*), although this should only be regarded as an order of magnitude value since the reflecting layer is probably not at the base of the atmosphere.

The stability fields of the iron oxides as determined from thermochemical data (*5*) show that the limiting value of pCO_2 to pCO corresponds approximately to the center of the magnetite field at 700°K. Higher values could extend to the field of hematite, however, and this extension would be possible without pO_2 exceeding 10^{-21} atm. This is significant in interpreting the failure to detect oxygen. Therefore, the data seem to indicate that metallic iron is not present in the surface rocks of Venus, but if these rocks do lie in the field of hematite, one would expect most of the iron to occur as oxides rather than silicates of iron. Since the latter consist chiefly of ferrous oxide, they would tend to be unstable under highly oxidizing conditions (*6*). Thus, if a quasi-equilibrium exists on Venus, the low values of pO_2 may correspond to a buffering of the atmosphere by the great mass of the lithosphere.

There are interesting questions concerning the stabilities of water and the reduced carbon species on Venus. The water-gas reaction shows that pCO_2 to $pCO \geq 10^3$ corresponds to pH_2O to $pH_2 \geq 10^{2.1}$ at 700°K. For the hydrocarbons, reaction 1 is informative

$$2H_2 + 2CO \rightleftharpoons CO_2 + CH_4 \qquad (1)$$

The relation between the equilibrium constant and the gaseous fugacities is

$$\frac{p^2CO}{pCO_2}\,K = \frac{pCH_4}{p^2H_2} \qquad (2)$$

At 700°K, $K = 10^{4.52}$, and if pCO to $pCO_2 = 10^{-3}$, then pCH_4 to $p^2H_2 = 10^{-0.48}$. Thus reaction 1 is displaced to the left by the oxidizing conditions. Polymers in the higher paraffin series would be even less abundant.

The stability of free carbon may also be evaluated by the use of the reaction

$$CO_2 + C\ (\text{graphite}) \rightleftharpoons 2CO \qquad (3)$$

where the equilibrium constant is $10^{-3.68}$ at 700°K. At the limiting value of 10^3 for the ratio pCO to pCO_2, this corresponds to $10^{2.32}$ for pCO_2, which is greatly in excess of the observed value. Thus the atmosphere is probably too oxidizing for free carbon to exist at the pressure attained at the rock surface.

The upper limit on pCO_2 of perhaps a few tens of atmospheres also permit deductions of the stability relations of certain carbonate phases. These deductions are subject to the uncertainties in the thermochemical data which may be considerable for the more complex minerals. Unfortunately, experimental data do not extend to the low fugacity range needed here. According to Week's data (*7*), the magnesium carbonates, magnesite and dolomite, should not be stable in the presence of free silica, but calcite might be stable with silica under the conditions of temperature and fugacity of carbon dioxide which is inferred for Venus. However, the stable occurrence of dolomite in the absence of free silica does seem possible.

The occurrence of the important class of rock-forming hydrous silicates is more doubtful. Extrapolation of data