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TITLE: ATMOSPHERIC CARBON DIOXIDE AND MARINE INTERACTION

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EXECUTIVE SUMMARY

This report studies causes which explain the recorded atmospheric annual CO₂ flux variation of about 5 parts per million (ppm). The amount is part of an annual CO₂ flow of about 28 ppm (221Gt) through the seasonal transfer of atmospheric CO₂ between the southern and northern oceans. The flow is driven by changes in sea temperature which also controls the concentration of CO₂ in the atmosphere as per Henry's Law. (See www.bosmin.com/HenrysLaw.pdf) Anthropogenic CO₂ is up to 36Gt which adds 16% to the current natural flux. While this is a notable portion, there is no satellite evidence to suggest there is an association between rising atmospheric levels of CO₂ and surface temperature. On the contrary, surface temperatures have remained flat for two decades while CO₂ levels have continued a modest rise.

Under constant climatic conditions, increased CO₂ levels in the air and sea will enhance both the marine and terrestrial food chains until a new balance point is reached for the available CO₂. Geological factors which affect deep sea temperatures by very small amounts have the potential to greatly influence the atmospheric concentration of CO₂. A 84 ppm increase of atmospheric CO₂ has been recorded over the past 30 years, and a 0.46 °C temperature increase in the sea surface temperature has caused this rise, as recorded in satellite records. There is reported to be some correlation between sunspot activity and sea surface temperature. However the more immediate impact on sea temperature is most likely due to variations in Earth's submarine tectonic activity. General science proves sea

temperature variations directly effect the atmospheric CO₂ concentration. It is important to note the sea must heat before the CO₂ levels rise - not the other way around. It is not possible to alter the atmospheric concentration of CO₂ by changing "carbon" emissions.

Asteroid impacts with the ocean have the potential to induce a general extinction of air breathing animals through the liberation of lethal levels of CO₂ to the atmosphere, as does heightened activity along the submarine Mid Atlantic Ridge.

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1. INTRODUCTION.

It has been postulated that aggregated atmospheric carbon dioxide levels cycle annually through a range of about 5 ppm (see Figure 1), because of the northern hemisphere flora contributions. (Refer United Nations "IPCC" reports and "An Inconvenient Truth" film by Al Gore).

Further description is contained in Webliography reference [W2](#):

"Superimposed on the aforementioned processes (industrial generated CO₂) are small (<2% peak to peak) annual oscillations in the atmospheric CO₂ concentration due to the 23.5 degree inclination of the Earth's rotation axis with respect to a normal to the plane of its orbit. This inclination causes the summer and winter seasons. There is also the fact that the area of the ocean in the southern hemisphere is much greater than the area of the ocean in the northern hemisphere and conversely the land area in the northern hemisphere is much greater than the land area in the southern hemisphere.

Consider what happens when it is winter in the northern hemisphere and summer in the southern hemisphere. Most of the land mass is in the northern hemisphere. In the northern winter there is very little photosynthesis by land based plants, so that absorption of CO₂ from the atmosphere by living plants almost stops. Decaying plants liberate more CO₂ to the atmosphere. Meanwhile in the southern hemisphere, which is mostly ocean, it is summer. Evaporation increases releasing yet more CO₂. Hence when it is winter in the northern hemisphere there is a net increase in atmospheric CO₂ concentration.

Consider what happens when it is summer in the northern hemisphere and winter in the southern hemisphere. The plant life in the northern hemisphere flourishes and absorbs CO₂. The ocean evaporation decreases reducing the rate of release of CO₂. Hence when it is summer in the northern hemisphere there is a net decrease in atmospheric CO₂ concentration."

This statement ignores the CO₂ reabsorption effects of the southern oceans during the cold periods by simply referring to a "reducing rate of release of CO₂".

It is an aim of this study to quantify the southern ocean's seasonal temperature effects on atmospheric CO₂ levels.

[W6](#) provides annual CO₂ cycle as illustrated in Figure 1 - also known as The Keeling Curve. This is based on Recent Monthly Mean CO₂ readings at Mauna Loa by NOAA, which includes an alternative graph where the underlying up trending level has been removed from the figures leaving only the "basic" annual variation cycle equal to about 5.6 ppm.

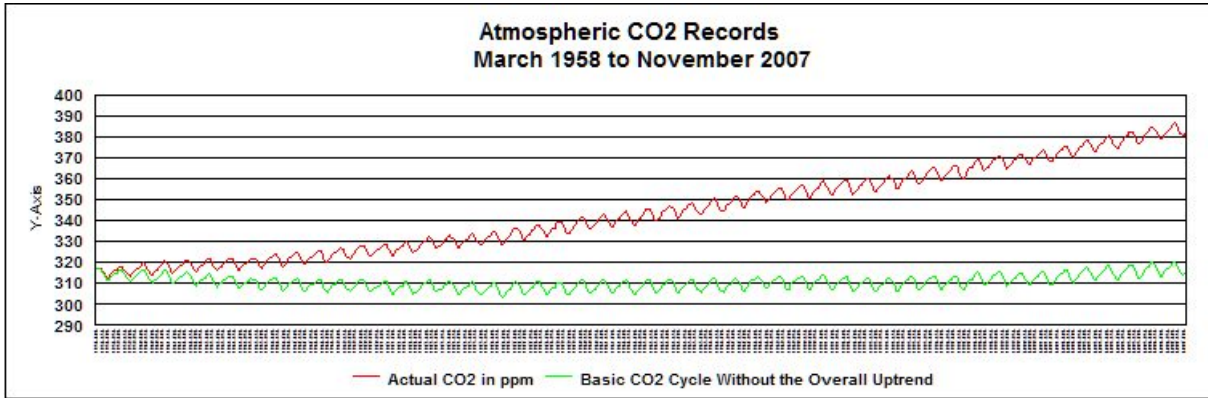


Figure 1

Figure 2 further analyses the three typical yearly records available from [W6](#) and divides them up into months when CO₂ levels were rising and falling.

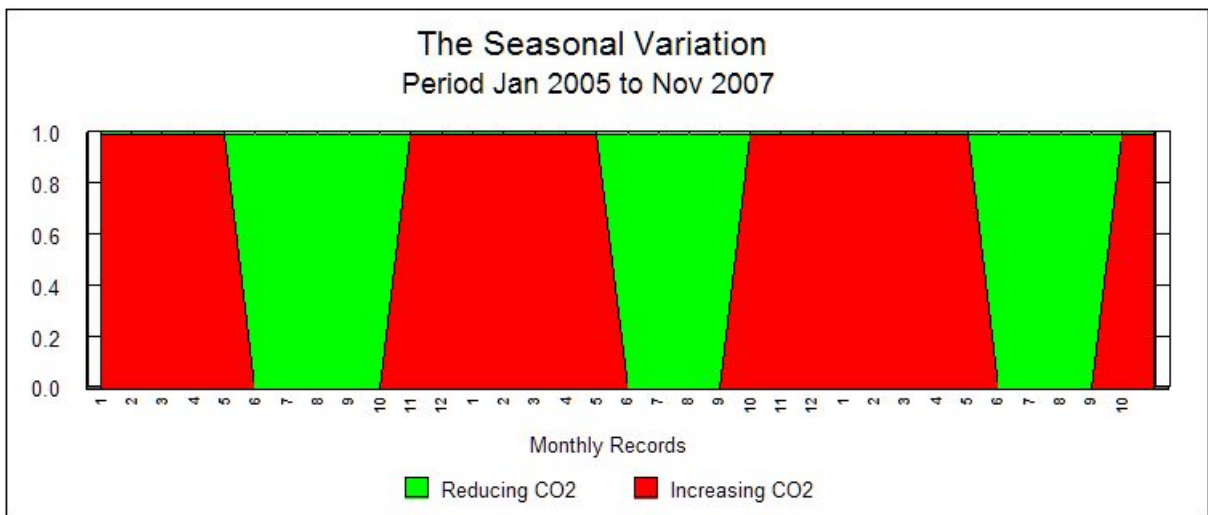


Figure 2

Interim Conclusion 1.

Asymmetric annual cycling of CO₂ in the atmosphere points to an unusually powerful driver to this system and closely connected to the Summer/Winter variation.

This investigation aims to check whether the southern ocean's rising temperature levels during the southern spring - summer period could plausibly explain the annual increase in atmospheric CO₂ levels, due to out gassing of southern oceanic CO₂ and subsequent reabsorption during the winter.

Figure 1. The "true" record shows a 66.64 ppm increase over the 1958-2007 period. Analysis of the "basic" record over the same period reveals 61% of the time, CO₂ levels are increasing while it takes only 39% of the time to reduce the CO₂ level.

Figure 2 shows the rapid CO₂ reduction period predominantly occurs during the months June, July, August, as illustrated in the most recent 35 month segment. This equates to the northern hemisphere summer solstice and start of autumn, while the southern hemisphere is experiencing mid winter and early spring solstices.

This time variation is consistent with CO₂ emanating from sea water, where a cold sea surface absorbing CO₂ will sink quickly due to increased density of cold water. So in the winter months CO₂ will be rapidly absorbed into the ocean depths aided by the convection effect. Alternately, in the summer months, a warmer sea will tend to float as a blanket on the ocean and restrict rapid exhaling of CO₂.

This raises the questions:

- ▶ Whether the rapid CO₂ reduction reflects a three month delay, but is caused by starting the northern hemisphere spring - summer period (flora effect)?
- ▶ Or, is it a more immediate cause and effect phenomenon due to the cooling of southern hemisphere oceans with re absorption of CO₂ (sea effect)?
- ▶ A third possibility is that it is a component of both?

These questions can be largely resolved by calculating the southern ocean impacts on the CO₂ flux change as displayed in the atmospheric records.

Scientific factors which need to be considered in this study include:

- ▶ The level of CO₂ dissolved in sea water.
- ▶ Temperature variations affecting CO₂ concentration.
- ▶ The area of affected ocean.
- ▶ The depth of ocean mixing.
- ▶ Variations in ocean salinity.

2. CARBON DIOXIDE DISSOLVED IN SEA WATER.

Henry's Law defines the amount of CO₂ passing between the atmosphere and the oceans, and states: *The amount of any given gas that will dissolve in a liquid at a given temperature is a function of the partial pressure of the gas in contact with the liquid and the solubility coefficient of the gas in the liquid.*

[W37](#) states "From the foregoing discussion it can be seen that the total CO₂ in sea water does not follow Henry's law for the solution of gases in inert solutions. Nevertheless, the partial pressure of the carbon dioxide in sea water in contact with the atmosphere will tend to establish equilibrium with that in the air. If the pressure is increased the amount in solution will be greater, and if it is reduced the quantity of CO₂ will decrease. The quantity present in a sample of water in equilibrium with a given carbon dioxide pressure will depend on the concentration of carbon dioxide bound base and the temperature and salinity of the water sample. If these factors are kept constant, the partial pressure of CO₂ can be used as a measure of the total carbon dioxide content of the water."

We therefore generalise that gaseous CO₂ follows Henry's Law when dissolving in sea water, it has the added property of being very reactive with water. Therefore as some of the gaseous CO₂ dissolves, it rapidly converts to the bicarbonate and then at a slower pace to carbonate radicals:

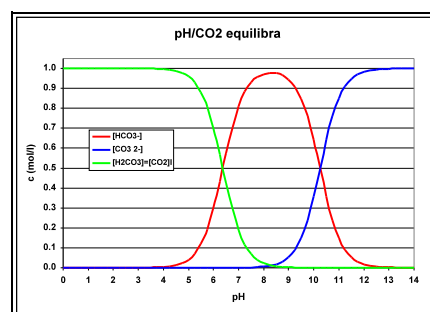
- (1) CO₂(g) ⇌ CO₂(aq)
- (2) CO₂ + H₂O ⇌ H⁺ + HCO₃⁻ and
- (3) H⁺ + HCO₃⁻ ⇌ 2H⁺ + CO₃²⁻

These are reversible acid-based reactions which characteristically reach equilibrium quickly, indicating that sea water effectively constitutes a large CO₂ "marshalling yard".

The relative concentrations of CO₂ in sea water are given as aqueous (1%), bicarbonate ion (93%) and carbonate ion (6%) ([W1](#))

The relationship between these components and ocean acidity is illustrated at ([W36](#)) where bicarbonate concentration reaches a maximum at the common sea pH between 7.5 and 8.4

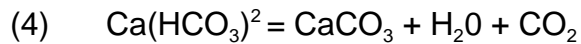
The large bicarbonate fraction of CO₂ remains stable under normal ocean conditions, but it partly dissociates when temperature approaches 50 °C (refer PJ Durrant, *General and Inorganic Chemistry*, pp355) "- carbon dioxide is evolved and crystals of calcium carbonate trihydrate, CaCO₃·3H₂O, are deposited." The highest sea surface temperature recorded ([W38](#))



was 96°F (35.6°C) in the Persian Gulf. However, a meteor impact with the ocean would cause the critical 50°C temperature to be exceeded. (See 8. Corollaries)

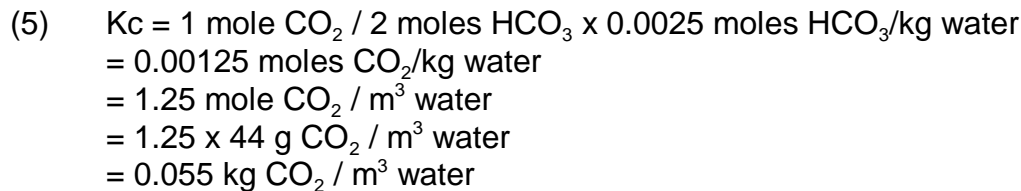
3. SEA SHELLS

Much higher temperatures are required to release the remaining CO₂ from the CaCO₃ and it is stable in oceanic systems. However, under normal sea conditions the calcium bicarbonate compound may be imagined as a huge floating lime deposit, which marine creatures discovered drifting past their front door, and ideal for home building.



The calcium carbonate goes to form the shell, but the CO₂ is not liberated - it gets transformed by the animal into carbon utilised to form the body mass, and the oxygen releases into the sea water. When the sea creature dies, the shell deposits on the sea floor and the carbonaceous body decomposes slowly or oxidises depending on marine conditions.

There is a possibility of releasing some calcium bicarbonate CO₂ from the sea, if the water temperature ever rises to about 50 °C. However, the natural highest sea temperature ever recorded reached 38 °C, well below this critical release temperature. When sea water is heated above 50 °C it releases one mole of CO₂ (44g) for every two moles of bicarbonate ion, as shown in ([W2](#)).



This increases the total CO₂ available from sea water heated above 50 °C to include both the bicarbonate and carbonic acid loads to:

$$(6) \quad 0.055 + 0.000,731,25 = 0.0557 \text{ kgCO}_2/\text{m}^3.$$

There is additional CO₂ tied up as CaCO₃ but is not generally available for release until temperatures reach 710-750 °C. ([W33](#)).



4. SENSITIVITY OF DISSOLVED CARBON DIOXIDE IN THE OCEANS.

The solubility coefficient of carbon dioxide gas (ppm) in sea water at atmospheric pressure, as tabulated in [W3](#) and [W2](#) shows:

DISSOLVED CARBON DIOXIDE GAS:

*The temperature and salt concentration dependent solubility **coefficient x 10²** of carbon dioxide gas in sea water is given by the following table from:*

NIST CO₂ Solubility in Sea Water. The units are mol kg⁻¹ atm⁻¹

TEMPERATURE	No Salt	3.4%	3.5%	3.6%	3.8%
273.15 K	7.758	6.325	6.287	6.249	6.175
283.15 K	5.367	4.413	4.328	4.363	4.313
293.15 K	3.916	3.258	3.241	3.223	3.189
303.15 K	2.995	2.530	2.517	2.505	2.480
313.15 K	2.389	2.054	2.045	2.036	2.018

Interim Conclusion 2.

CO₂ digestion in sea water is quite sensitive to varying salt levels and particularly sensitive to changes in temperature.

The above tabulation can generally be described through least square combination, in the following equations:

Dissolved CO₂ gas in moles per kilogram at atmospheric pressure.

$$(8) \quad ((10.34029 - 2.15471 \times \text{LN}(T)) - (0.59584 - 0.13464 \times \text{LN}(T))) \times S$$

Where T is sea temperature in °C, and S is the percentage salt content in sea water.

This equation is found to be accurate to ±1.2% for T range 4 °C to 40 °C.

For T less than 4 °C and greater than ice freezing temperature of -1.7 °C in sea water (NB CO₂ is expelled from ice), and S less than 3.4%, the following relationship applies:

$$(9) \quad (7.758 - 0.2391 \times T) - (0.42147 - 0.01409 \times T) \times S$$

A formula for spreadsheet simulation of these conditions is:

$$(10) \quad @\text{IF}(S \geq 0 \# \text{AND} \# S < 3.4 \# \text{AND} \# T < 4, (7.758 - 0.2391 * T) - (0.42147 - 0.01409 * T) * S, (10.34029 - 2.15471 * @\text{LN}(T)) - (0.59584 - 0.13464 * @\text{LN}(T)) * S)$$

Worked example following [W3](#):

The partial pressure of CO₂ over the Pacific Ocean is about 400 ppm concentration. The table above shows that for T=10 °C (283.15 K), and S=3.5% salinity the amount of CO₂ gas in solution is given by:

$$(11) \quad \text{The partial pressure is given by } 400 \times 10^{-6} \times (44/28.84) [\text{SGCO}_2/\text{SGair}] \\ = 610.26 \times 10^{-6} \text{ atmospheres}$$

The tabulation above at 10°C (283.15K) and 3.5% salinity shows the equilibrium amount of CO₂ in sea solution is given by:

$$(12) \quad 0.04328 \text{ [moles/kg-atmosphere]} \times 610.26 \times 10^{-6} \text{ [atmospheres]} \\ = 26.412 \times 10^{-6} \text{ moles/kg}$$

$$(13) \quad \text{The corresponding maximum density of CO}_2 \text{ at sea surface is:} \\ 26.412 \times 10^{-6} \text{ [moles/kg]} \times 10^3 \text{ [water/m}^3\text{]} \times 44 \text{ [gCO}_2\text{/mole]} \times 1/10^3 \text{ [g to kg]} \\ = 1162.1 \times 10^{-6} \text{ kg CO}_2\text{/m}^3 = 0.0011621 \text{ kg CO}_2\text{/m}^3$$

$$(14) \quad \text{Under these conditions, the conversion (Rhodes Ratio) is:} \\ 1 \text{ ppm is equivalent to } 0.0011621/400 = 2.90532 \times 10^{-6} \text{ kg CO}_2\text{/m}^3$$

Equation (5) explains the situation for temperatures above 50°C. Under these circumstances, (13) is increased by 0.055 kgCO₂/m³ sea water. A provisional statement is added to the spreadsheet calculation to record this option.

Equation (7) explains the situation for temperatures above 750°C, and another provisional statement is added to (13) to cover that eventuality and increased by a further 0.055 kgCO₂/m³ sea water.

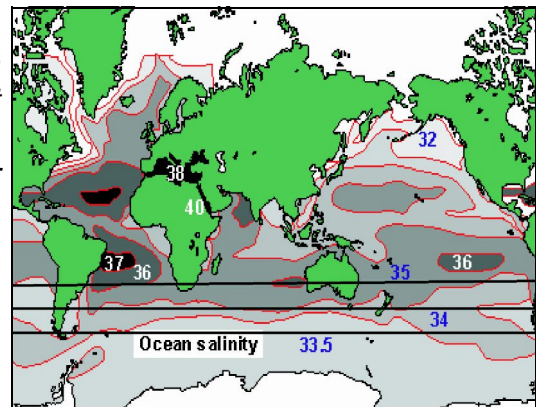
[W12](#) converts mass of CO₂ in the atmosphere to parts per million by volume (ppmv) CO₂ as approximately 7.8 Gt (10⁹ t) of CO₂ corresponding to 1 ppmv:

$$(13) \quad \sim 7.8 \text{ Gt (10}^9 \text{ t)} = 1 \text{ ppmv}$$

5. SENSITIVITY TO SALINITY.

Reference [W1](#) includes:

“This world map shows how the salinity of the oceans changes slightly from around 32ppt (3.2%) to 40ppt (4.0%). Low salinity is found in cold seas, particularly during the summer season when ice melts. High salinity is found in the ocean 'deserts' in a band coinciding with the continental deserts.”

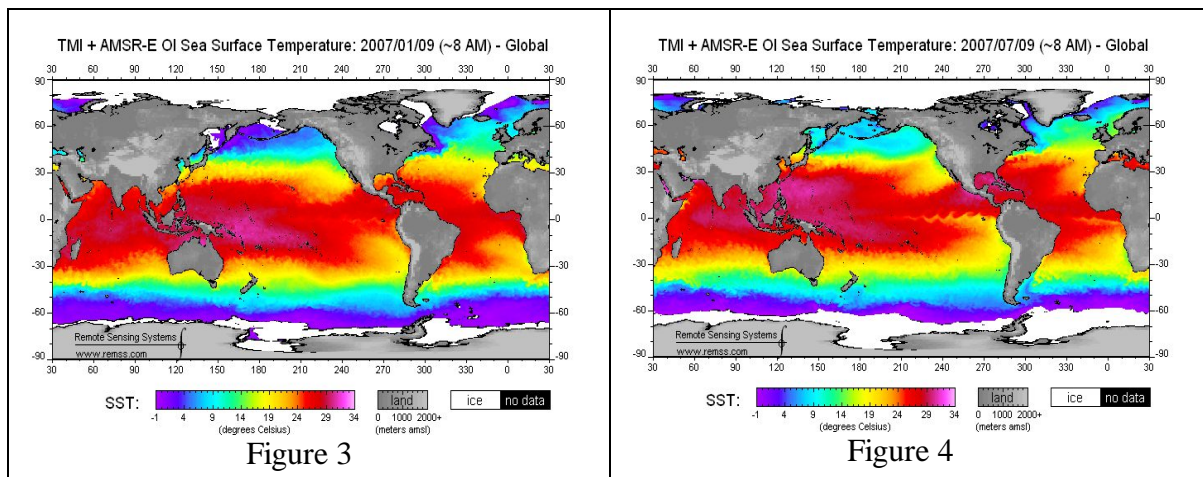


Estimates of the weighted average salinity levels are:

- (14) Zone 1. (0°S→20°S) = 3.470%
- (15) Zone 2. (20°S→35°S) = 3.503%
- (16) Zone 3. (35°S→50°S) = 3.426%
- (17) Zone 4. (50°S→65°S) = 3.353%

6. SENSITIVITY TO TEMPERATURE

Figures 3 and 4 illustrate sea surface temperature isothermal colours for 9th January 2007 and 9th July 2007 respectively. Refer Remote Sensing Systems [W11](#).



While the temperature regions may vary from year to year, the general trend is reliably illustrated by the figures. If we consider the southerly latitude bands, it is apparent average sea surface temperature has changed as follows:

- (18) Zone 1. (0°S→20°S) = 26 °C to 28.5 °C
- (19) Zone 2. (20°S→35°S) = 21 °C to 24 °C
- (20) Zone 3. (35°S→50°S) = 10 °C to 14 °C
- (21) Zone 4. (50°S→65°S) = 0 °C to 3 °C

To the south of Zone 4 lies Antarctica, and a small area of ocean with seasonal variation in the extent of sea ice. This has an interesting effect on dissolved CO₂ and salt. Ice formed from sea water expels these constituents during freezing at -1.7°C.

6.1. OCEAN AREAS OF INFLUENCE.

The southern ocean region between 0° (equator) and 65° south is the largest area of ocean affected by the annual surface temperature changes.

Sea surface area between two points of latitude declination may be calculated from the formula:

$$(22) \quad \text{Area (Lat}_1 \rightarrow \text{Lat}_2) = 4 \times 0.5(\text{hemisphere}) \times \text{Pi} \times \text{R}^2 \times (\sin(\text{Lat}_1^\circ) - \sin(\text{Lat}_2^\circ)) \times \text{P}$$

$$= 254.9 \times 10^6 \times (\sin(\text{Lat}_1^\circ) - \sin(\text{Lat}_2^\circ)) \times \text{P square kilometres}$$

Where R is the earth's radius (6,369.4km) and P is the portion of sea to land.

$$(23) \quad \text{Zone 1. (0}^\circ\text{S} \rightarrow \text{20}^\circ\text{S), P=0.78, Area} = 509.8 \times 10^6 \times (\sin 20 - \sin 0) \times 0.78$$

$$= 68.0 \text{ million km}^2$$

$$(24) \quad \text{Zone 2. (20}^\circ\text{S} \rightarrow \text{35}^\circ\text{S), P=0.73, Area} = 43.1 \text{ million km}^2$$

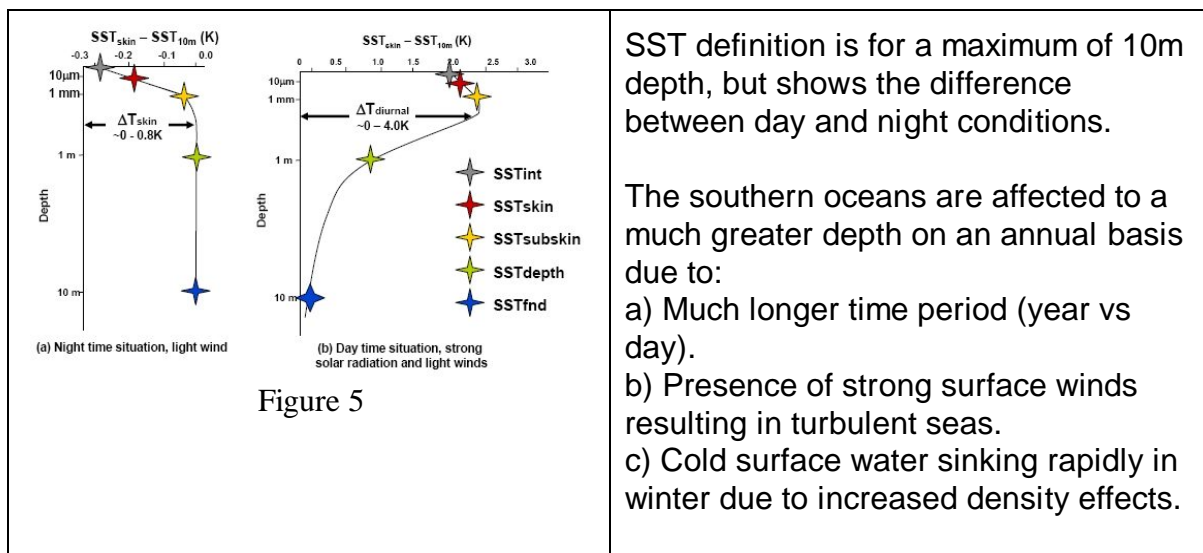
$$(25) \quad \text{Zone 3. (35}^\circ\text{S} \rightarrow \text{50}^\circ\text{S), P=0.96, Area} = 47.1 \text{ million km}^2$$

$$(26) \quad \text{Zone 4. (50}^\circ\text{S} \rightarrow \text{65}^\circ\text{S), P=0.99, Area} = 35.4 \text{ million km}^2$$

$$(27) \quad \text{Total area} = 193.6 \text{ million km}^2$$

6.2. SEA COLUMN DEPTH ASSUMPTION.

Sea Surface Temperature (SST) is defined at [W4](#) where Figure 5 is shown.



W13 comments:

The thickness of the surface mixed layer (at a research site in the northwestern Sargasso Sea) shows a large seasonal variability mainly caused by the large seasonal changes in the heat exchange and wind stress at the surface (Musgrave et al., 1988; Doney et al., 1996). Maximum mixed layer depths are found in late winter/early spring with depths ranging from 150 to 300 m. Afterwards the layer shoals, but the transition is highly erratic owing to intermittent convective events and restratification acting on a weak vertical density gradient. In June, a stable shallow mixed layer of about 20 m is established, which lasts until beginning of August. Then the layer gradually deepens as a result of cooling and increased wind stress until the time of maximum vertical overturning in February/March.)

W5 records measured annual mixed layer depth in a study area off Westland (NZ) over an 11-year period reaching 110 to 190m below the sea surface, and noted “A parameters of prime importance in the mixing model is the wind speed.”

Further summary comment included:

The annual range of mixed layer depth, from up to 200 m in winter to between 10 and 40 m in summer, seems to be modelled well. The large interannual variability of the deepest winter mixing is interesting: the calculated mixed layer depth reached 195 m in 1986, but only 152 m in the year before.

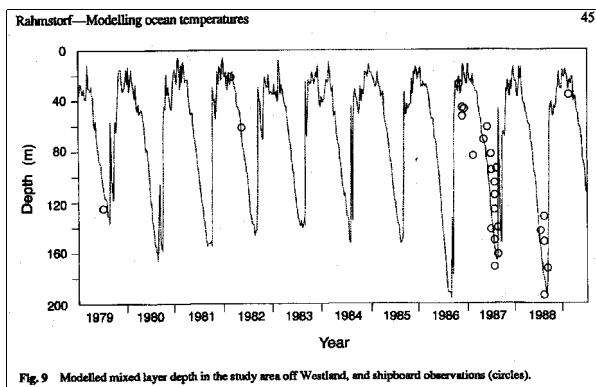


Fig. 9 Modelled mixed layer depth in the study area off Westland, and shipboard observations (circles).

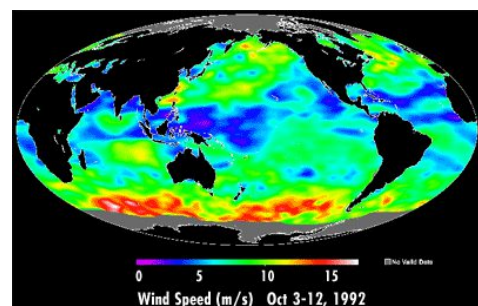
The minimum depth of penetration during the winter months is 140m.

W14 tabulates a typical Ekman relationship for sea mix depth as:

Wind Speed at 10m above the sea (m/s)	Latitude 15°	Latitude 45°
18kph (5 m/s)	75 m	45 m
36kph (10 m/s)	150 m	90 m
72kph (20 m/s)	300 m	180 m

W29 shows a satellite image over a nine day period with wave height interpretation defining implications for the surface wind speeds, as shown.

Latitude 15° is applicable to Zone 1, showing wind speed in the equatorial region of about 5m/s. This equates to Ekman mix layer depth of 75m.



Note; equivalent Latitude 45° depths are less, due to the Coriolis force.

Latitude 45° tabulation has a straight line correlation:

$$(28) \quad \text{Wind Speed (m/s)} = 0.00005 + 0.1111 \times \text{Depth(m)}$$

Zone 2 has winds about 7 kph. Using (28) shows this equates to a mix layer depth of 63m

Applying the 140m depth found in the preceding Westland study to the Ekman tabulation indicates a minimum winter wind speed 15.55m/s. This is considerably higher than the wind speeds suggested in the Westland study in the range 7-15m/s, or [W29](#) and indicates factors other than wind are involved in layer depth effects.

Interim Conclusion 3.

The most significant factor in determining the depth of a thick ocean mix layer is the presence of a descending convection current formed when colder surface water sinks due to its higher density. Wind is the second significant factor.

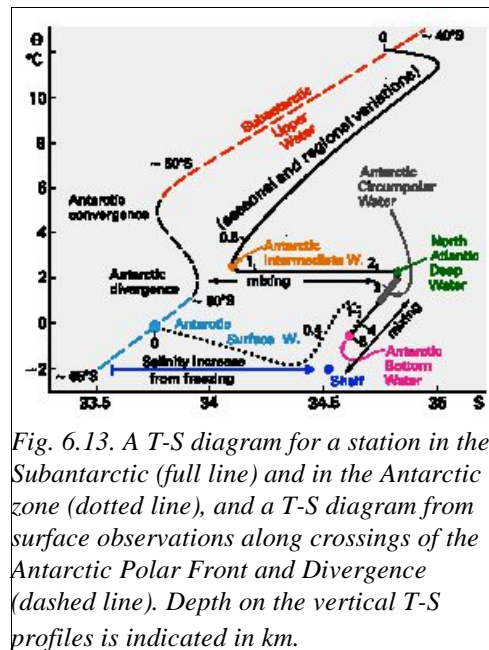


Fig. 6.13. A T-S diagram for a station in the Subantarctic (full line) and in the Antarctic zone (dotted line), and a T-S diagram from surface observations along crossings of the Antarctic Polar Front and Divergence (dashed line). Depth on the vertical T-S profiles is indicated in km.

[W15](#) states:

The intense mixing processes which form the water masses of the Southern Ocean come out clearly if a T-S (Temperature/Salinity) diagram of surface observations along a meridional line of stations is compared with T-S diagrams from stations in the Antarctic and Subantarctic zones (Figure 6.13). Both profiles start at the T-S point of Antarctic Bottom Water and end on the surface T-S curve but do this in distinctly different ways. In the Antarctic zone, water at the surface has very low temperatures, ranging down to the freezing point of -1.9°C, and low salinities as a result of ice melting in summer. In a hydrographic station in this zone (the dotted line in Figure 6.13) the influence of this low surface salinity is felt in the upper 100 - 250 m; this water is called Antarctic Surface Water. In the Subantarctic zone, surface water has a larger temperature and salinity range since seasonal variations of solar heating, rainfall, and evaporation become more important. The temperature range of this Subantarctic Upper Water spans 4 - 10°C in winter and 4 - 14°C in summer, with a salinity varying between 33.9 and 34.9 and reaching as low as 33.0 in summer as the ice melts. This produces a shallow surface layer of low salinity and an intermediate salinity maximum between 150 m and 450 m depth, as seen in the T-S data of the station from the Subantarctic zone (the full line in Figure 6.13). The difference between the full line and the dashed line in the T-S range of the Upper Water indicates that the figure compares data from different seasons. There are also variations between the various sectors of the zone, with lowest salinities in the Pacific and highest in the Atlantic sector.

Interim Conclusion 4

W15 work shows the Antarctic Surface Water (ASW) has influence over 100-250m depth, and the Subantarctic 150-450m. The ASW is noted for changing salinity levels with the lower salinity readings occurring during the summer melt period.

Southern oceans are notoriously wind swept and the annual mixed layer depth may be expected to increase with additional wind velocity and sea convection.

W29 Average wind speeds are estimated as follows:

- (29) Zone 2. 20°S→35°S = 7mps,
- (30) Zone 3. 35°S→50°S = 10mps,
- (31) Zone 4. 50°S→65°S = 14mps.

W7 displays a relationship between surface layer mix and wind velocity:

A least square combination which best fits this data is:

$$(32) \text{ Layer mix depth in metres} = 0.00135 \times V^{4.81605}$$

Where V is the wind velocity in metres per second.

The derived ocean mix depths become:

- (33) Zone 2. 20°S→35°S = 16 metres.
- (34) Zone 3. 35°S→50°S = 88 metres.
- (35) Zone 4. 50°S→65°S = 456 metres.

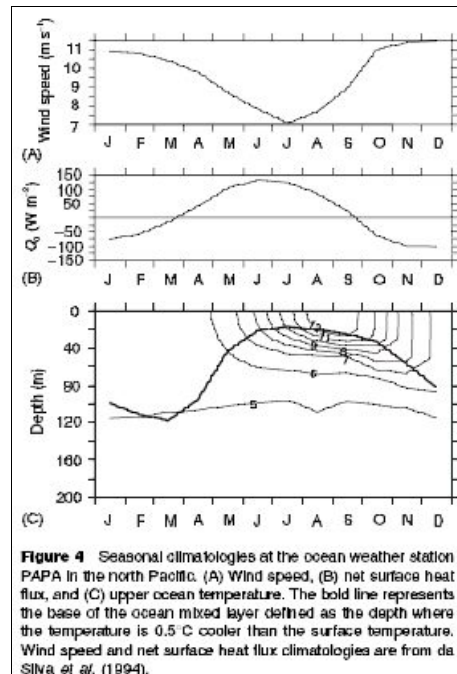


Figure 4 Seasonal climatologies at the ocean weather station PAPA in the north Pacific. (A) Wind speed, (B) net surface heat flux, and (C) upper ocean temperature. The bold line represents the base of the ocean mixed layer defined as the depth where the temperature is 0.5 C cooler than the surface temperature. Wind speed and net surface heat flux climatologies are from de Silva *et al.* (1994).

Interim Conclusion 5

Mix depths of 63m, 16m and 88m seem appropriate for the first three Zones of influence, but Zone 4 appears to be excessive, (probably caused by over extrapolation of equation (28)). Given the 100m-450m range deduced in Interim Conclusion 4, Zone 4 will assume the average 275m depth profile.

The volumes of sea water involved are respectively:

- (36) Zone 1. 0°S→20°S = 68 x 75 = 5.10 million cubic kilometres
- (37) Zone 2. 20°S→35°S = 16x 43.1 = 0.69 million cubic kilometres
- (38) Zone 3. 35°S→50°S = 88x 47.1 = 4.14 million cubic kilometres
- (39) Zone 4. 50°S→65°S = 275x 35.4 = 9.73 million cubic kilometres
- (40) Total = 19.7 million cubic kilometres

6.3. CARBON DIOXIDE FLUX CALCULATIONS

CO₂ solubility is a function of the gas concentration in the atmosphere as shown in equation (12).

[W6](#) records the CO₂ concentration at Mauna Loa in November 2015 range from 397, and 404ppm. These values are adopted in the following calculations, to correspond with the southern summer and winter, respectively.

	Salinity	Temperature		CO ₂ Solubility Coefficient x 10 ²	
		Winter	Summer	Winter	Summer
		°C	°C	molCO ₂ /kgSea	
Zone 1. (0oS 20oS)	3.470	26	28.5	2.775	2.62
Zone 2. (20oS 35oS)	3.503	21	24	3.129	2.904
Zone 3. (35oS 50oS)	3.426	10	14	4.400	3.830
Zone 4. (50oS 65oS)	3.353	0	3	6.345	5.769

TABLE 1

These values are entered into a spreadsheet based on the CO₂ solubility data provided by the Nation Institute of Standards and Technology (Section 4) and the calculations shown in reference [W2](#). The previously estimated values for the Zones 1-4 are input into spreadsheet equation (11) to develop Tables 2 and 3:

	Salinity	Temperature		CO ₂ Solubility		CO ₂ Dissolved		Surface	Annual Flux
		Winter	Summer	Winter	Summer	Winter	Summer	Increment	Component
		°C	°C	397.00	404.00	x10 ⁻⁶ moles/kgkg CO ₂ /m3		ppm	
Zone 1. (0oS 20oS)	3.470	26	28.5	1.68E-005	1.61E-005	7.39E-004	7.10E-004	2.90E-005	9.10
Zone 2. (20oS 35oS)	3.503	21	24	1.90E-005	1.79E-005	8.34E-004	7.88E-004	4.62E-005	8.14
Zone 3. (35oS 50oS)	3.426	10	14	0.00003	2.36E-005	1.17E-003	1.04E-003	1.34E-004	5.96
Zone 4. (50oS 65oS)	3.353	0	3	3.84E-005	3.56E-005	1.69E-003	1.56E-003	1.26E-004	4.05
								Total ppm flux	27.25
								Giga Tonnes	212.58

TABLE 2.

[W40](#) by the late Emeritus Professor Lance Endersbee provides an “experience curve” that establishes a relationship between sea surface temperature and atmospheric concentration of CO₂. It is a linear relationship showing good correlation.

$$(41) \quad \text{Parts per Million CO}_2 = 143.6 \times \text{Incremental sea surface temperature} + 334.1$$

	TemperatureCO ₂ Solubility x 10 ²					Increment	Surface	Mix Layer	Mix Layer	Mix Layer Weighted
	Salinity	Winter	Summer	Winter	Summer		Area	Depth	Volume	Annual Flux
	%	°C	°C	molCO ₂ /kgSea			km2	m	m3	ppm
Zone 1. (0oS-20oS)	3.470	26	28.5	2.775	2.620	23.9	6.80E+007	7.50E+001	5.10E+015	6.20
Zone 2. (20oS-35oS)	3.503	21	24	3.129	2.904	28.7	4.31E+007	1.60E+001	6.89E+014	1.01
Zone 3. (35oS-50oS)	3.426	10	14	4.400	3.830	38.3	4.71E+007	8.80E+001	4.14E+015	8.07
Zone 4. (50oS-65oS)	3.353	0	3	6.345	5.769	28.7	3.54E+007	2.75E+002	9.73E+015	14.21
						29.5	193,584,871	1.02E+002	1.97E+016	29.49
									Giga Tonnes	230

TABLE 3.

Tables 2 and 3 show slightly different, but very comparable values for the seasonal CO₂ flux migration between the hemispheres. They are 27.25ppm (213Gt) and 29.49ppm (230Gt).

This finding is significant because Table 3 is derived from theoretical calculations of CO₂ solubility in sea water, whereas Table 2 represents actual field measurements derived from satellite and measured atmospheric CO₂ content over a number of years. Both tabulations indicate that the sea can absorb the anthropological contribution to the annual flux of up to 36Gtpa (extra 15.6%) without moving off the established temperature dependent solubility curve derived in both calculation methods.

Critically, the results also show that the sea must heat before the CO₂ concentration can rise and not the reverse. This means that the rise in sea temperature alone is the driver for increasing levels of CO₂ - regardless of whether that rise is associated with 'global warming' or not.

The calculating logic includes:

- The annual sea surface variation of CO₂ (mainly stored as HCO₃⁻), is shown in Table 1 as varying during the winter and summer season changes.
- Calculations show atmospheric concentration of CO₂ is in balance with the sea surface concentration as defined by Henry's Gas Law.
- The average winter and summer CO₂ in the atmosphere (currently 400.5ppm) applies to the whole globe. Table 3 shows the concentration for the southern hemisphere moves up an additional 29.5ppm (Table 2: 27.3ppm) in summer indicating that CO₂ is flowing to the northern hemisphere where it is absorbed by those colder winter seas.
- The Mauna Loa records (Keeling curve) show a seasonal variation of 5-7ppm confirming the migrating nature of this CO₂ flux and establishing that CO₂ liberation is occurring simultaneously with absorption.
- The average of Table 2. and 3. shows the annual CO₂ flux travelling between the two hemispheres each year is 28 ppm, equivalent to 221 Gt.

The anthropogenic contribution to atmospheric CO₂ is reported as 36 billion tonnes (equivalent to 36 Gt) - other references suggest [26 Gt](#). So the anthropogenic portion of CO₂ is up to 0.163, or 16% of the natural flux. While this is a notable portion,

there is no satellite evidence to suggest there is an association between rising atmospheric levels of CO₂ and surface temperature.

On the contrary, surface temperatures have remained flat for two decades while CO₂ levels continue a modest rise.

Geological records show much higher levels of CO₂ have existed and been absorbed through natural processes. CO₂ in the air as well as in the ocean is undoubtedly associated with enhanced taxa development with no identifiable downside.

Reference [W40](#) shows there is a recorded increase in sea surface temperatures over recent years which basic science, shows must be causative of increased levels of CO₂ in the atmosphere. The National Institute of Standards and Technology theoretical tabulation for the solubility coefficient of carbon dioxide gas (ppm) in sea water at Section 4, closely matches the Endersbee "experience curve" which confirms the sea is operating within the theoretical limits for the current SST profile.

Interim Conclusion 6

Both theoretical and actual field measurements confirm the average CO₂ seasonal flux 221Gt pa and show the sea is operating within the anticipated limits for the current SST profile.

It is critical to note that the sea must heat before the level of atmospheric CO₂ can rise - not the other way around. This is important because it proves that increasing levels of anthropogenic produced CO₂ cannot cause the sea to heat initially - whether that additional CO₂ causes the global surface temperatures to rise or not.

Satellite records shows there is a recorded increase in sea surface temperatures over recent years which basic science, shows must be causative of increased levels of CO₂ in the atmosphere.

CO₂ is a heavy gas (1.5 times air) and remains in close contact with the sea surface. This permits rapid stoichiometric balancing of sea and atmospheric CO₂ during season changes.

7. OTHER IMPORTANT IMPACTS

7.1. NORTHERN OCEAN SUMMER IMPACTS

Further to Interim Conclusion 6, [W9](#) shows the world oceans have a surface area of 361 million km². Table 2 and (27) show a total of 194 million km² are allocated to the southern oceans (between 0° and 65° south), being the substantial part of the exposed southern hemisphere ocean area as further south is ice or land. This leaves 167-6 (Arctic Ice) = 161 million km² of sea expanse north of the equator, which are affected to varying degrees by seasonal temperature change.

However, as discussed the southern oceans had a mean release of 221Gt. If we assume a similar absorption of CO₂ concentration occurs in the northern oceans, it affects an average mix layer depth of $102 \times 194 / 161 = 123$ m of ocean surface before the required 221GtCO₂ is absorbed. This appears plausible and points to the crucial part oceans play in balancing the world's CO₂ budget. The greater depth (123m cw. 102m) may be a factor in the asymmetric cycling noted at Interim Conclusion 1.

Interim Conclusion 7

The 5-7ppm CO₂ variation noticed annually at Mauna Loa should be regarded as a function describing the level of atmospheric resistance experienced when migrating large volumes of CO₂ between the northern and southern hemispheres.

Combined CO₂ southern ocean zonal influence (28 ppm) is much higher than the variations recorded at Mauna Loa (eg 386.37-380.74 = 5.6ppm). This means that CO₂ is being simultaneously added to the atmosphere at a rate of around 28 ppm during the southern winter time (northern summer).

7.2. VEGETATION BALANCE

[W12](#) shows the annual CO₂ vegetation balance is neutral:

Atmosphere --> terrestrial vegetation 60Gt Net primary production
Soils & detritus --> atmosphere 60Gt Respiration

However, the recent higher levels of CO₂ in the atmosphere have been associated with improved crop yields.

Interim Conclusion 8

Figure 2 and Tables 2 and 3 calculations show the northern summer flora consumption of CO₂ is out of phase with the Mauna Loa records, but is in phase with the southern ocean surface temperatures, as further discussed in para 7.3. It is concluded that the vegetation balance is neutral and is a continuing system not hugely influenced by the seasonal marine variations.

7.3. KATABATIC WIND

The influence of Antarctic Katabatic wind on CO₂ mixing is worthy of note. Antarctica forms a high plateau (~2750m) surrounded by low-lying plains. Cold air forming on the plateau increases in density and falls over the edge creating katabatic wind. During the descent, air pressure increases further raising the density and accelerating the wind. Katabatic wind leaves the continent in a radial pattern which mixes with the “shrieking sixties, furious fifties and roaring forties” to form a series of barrelling wind eddies across the ocean and high into the atmosphere. This is further explained at www.bosmin.com/SawToothClimate.pdf

The wind chill effect on the sea surface is enhanced by this process making the sea more amenable to absorbing CO₂. The rapid air circulation presents large volumes of the atmosphere to the cold sea surface, thereby facilitating the rapid transfer of atmospheric CO₂.

Sea ice forming during Antarctic winter expels the entrained CO₂ which is swept further out to sea and quickly reabsorbed. This system is largely expected to account for the rapid drop in CO₂ concentration during the June to August period as recorded on [The Keeling Curve](#).

7.4. GLOBAL CO₂ TRENDS

[W6](#) shows that global CO₂ levels have increased by 84 ppm during the 57 year March 1958 to November 2015 period. This is equivalent to 655 GtCO₂ and raises the question of how much if any, of this gain can be explained by sea temperature change?

In applying Endersbee equation (41) from [W40](#) it shows a surface temperature increase of 0.59°C over the 57 year period is sufficient to increase the atmospheric concentration of CO₂ by 84ppm. The Endersbee paper shows measured sea surface temperature has risen 0.28°C over 23 years which most likely is caused through spasmodic exothermic activity occurring at various spreading ridge sites around the world.

7.5. ATLANTIC OCEAN INFLUENCE

The most obvious evidence for a general ocean heating is in the Atlantic Ocean where sea temperature increase appears to be responsible for partially melting the Greenland sea ice in the North Atlantic, and the Larsen Ice Shelf in the South Atlantic as discussed:

[W16](#) advises, “*The events (Larsen Ice Shelf break ups) all coincide with an observed 2.5 degree Celsius warming around the Antarctic Peninsula over the last 50 years*”

[W17](#) quotes "When we came here (Greenland) in 1990, the first two, three years were actually colder than normal. Then in 1994, 1995, it started to warm steadily and since then, we've had a temperature increase during the winter months of 4.5 degrees centigrade, 8.1 degrees Fahrenheit, which is very large, the largest temperature increase on earth."

7.6. ATLANTIC OCEAN HEAT SOURCE

[W19](#) The Atlantic ocean is known for hosting one of the world's most continuous mid ocean spreading ridges (MAR).

[W18](#) shows side scan images of MAR which exhibit the typical parallel ridge structure associated with these geological features. The parallel ridges are evidence that ridge formation occurs spasmodically. It is axiomatic that the heat associated with up welling of ridge magma also occurs in a spasmodic fashion. This will inevitably lead to temperature variations in the overlying ocean.

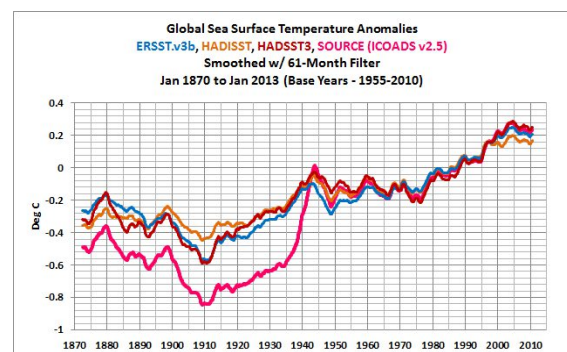
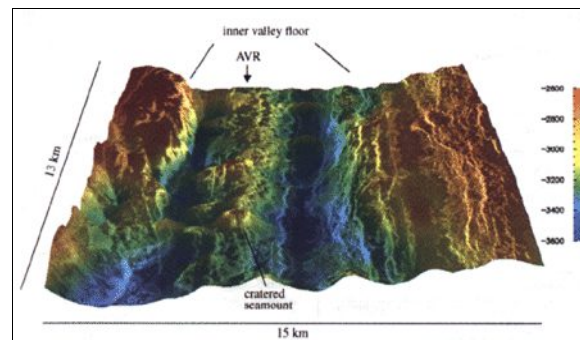
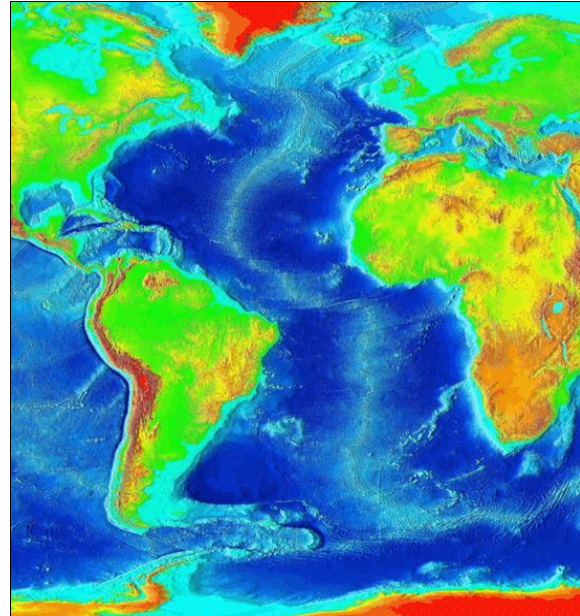
A correlation between storm activity and seismicity along the MAR is shown to exist at [W41](#).

[W9](#) confirms the Atlantic Ocean has a volume of 310.4 million km³ which represents about 23.3% of the world sea volume. It is revealing to calculate the rise in temperature required in this ocean to elevate the world atmospheric CO₂ levels from 334 in January 1985 to the December 2015 level of 400ppm. (66ppm)

Equation 42 indicates a general sea surface change of 0.46°C is required to establish a 400ppm

The Atlantic Ocean represents 23.3% of the total ocean volume indicating that the Atlantic Ocean core temperature rose by $0.46/0.233 = 1.97^{\circ}\text{C}$. This is consistent with [W16](#) and [W17](#) site information.

However, several other spreading ridges



are apparent throughout the oceans and total [80,000km](#) in length. Magma spasmodically erupts from these ridges at temperatures ranging between 700-1300°C, as well as numerous hydrothermal vents where water emerges at temperatures ranging from [60-464°C](#)

Reference [W42](#) shows historical sea surface temperature recordings from 1870 with the range varying from 0.6 to 1.0°C. It is interesting to note a moderating level of temperature rise since 2000.

Interim Conclusion 9

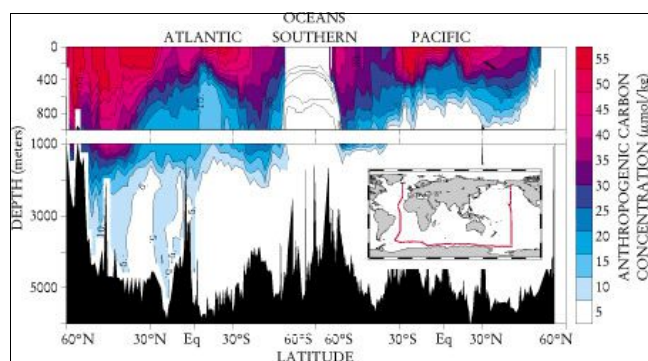
Ocean temperature has a dominant influence on the level of carbon dioxide gas present in the atmosphere and it is unsurprising that spasmodic seismic activity will influence the average sea surface temperature. A general sea surface temperature rise of 0.46°C is sufficient to exhale of 84 ppm of CO₂ to the atmosphere since 1985.

7.7. OVERALL INCREASING CO₂ ATMOSPHERIC CONTENT

[W2](#) finds that the total fossil carbon release (anthropogenic) rate in 2004 was 3.683×10^{10} tpa, equivalent to 36.8 GtCO₂pa, or 4.72 ppm. This quantity is modest when compared to the dramatic difference a small change in ocean temperatures can make, and is moderate when compared with annual natural CO₂ flux of 221 GtCO₂pa discussed at Interim Conclusion 6.

However, it does form part of Earth's CO₂ flux, but Conclusion 6 leaves no reason to doubt Earth's ability to absorb this flux addition without causing noticeable side effects.

[W27](#) Reports: *Model simulations suggest that the Southern Ocean around the Antarctic (south of 35 °S) accounts for nearly half of the net air-sea flux of anthropogenic carbon. Another sixth of the total uptake occurs in the tropics (13 °S to 13 °N). Those are both regions with large surface areas, where up welling (in the tropics and Southern Ocean) and deep vertical exchange (in the Southern Ocean) bring to the surface older, relatively uncontaminated deep water that has a high capacity for uptake of CO₂.*



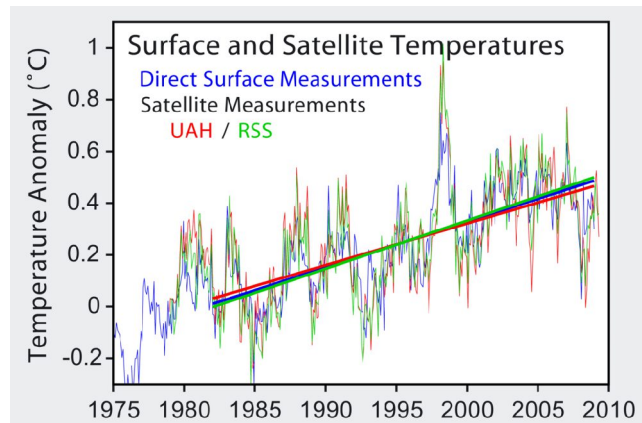
[W30](#) discusses the use of carbon 13:12 ratio to track anthropogenic CO₂. It is unsurprising to find that carbon 13 is so widely spread, or that it has a half life of 25 years in the atmosphere, given the modest portion it represents in the comparatively large annual flux. Nor is it surprising that it is traceable deep into the oceans.

However, it does present a graphic illustration of how widely all forms of CO₂ circulate in the world, but should not raise a cause for concern.

[W34](#) Details the satellite global sea surface temperature record 1978 to 2010 recorded by the National Space Science and Technology Center, which is expected to be more accurate readings than those shown in [W42](#).

The series trend has risen and shows an increase of 0.4°C over the past 33 years, or 0.012°C pa. This may be compared with the rate of CO₂ increase calculated in section 7.4

which gives an average temperature increase of 0.010°C per year over the past 57 years, a decline in the rate of heating by about 17%.



The lower rate of increase for the more recent years shown above might presaged an end to the ocean heating period, which leads to a stabilisation of atmospheric CO₂ levels.

However, surface temperature readings do mask temperature variations at deeper sea levels and so effects from reduced submarine tectonic activity can be expected to show significant time delays. Reference [W40](#) has used a 21 year moving average methodology to account for this effect.

Further cooling of the oceans would lead to lower CO₂ levels with an associated reduction in fertilizing effects.

Increased concentration of CO₂ in the sea has a fertilizing effect similar to that on land ([W39](#)). Phytoplankton thrives and the marine biological food chain increases accordingly. The CO₂ concentration level is well below toxicity levels of several thousand ppm and the net effect of more CO₂ in the atmosphere appear to be positive in that it enhances the food chain.

7.8. NATURAL CO₂ SEQUESTRATION

There is concern that sea creatures utilising more abundant Ca(HCO₃)² to build shell will result in more acidic oceans due to the liberation of CO₂ as shown in (4) and hence acetic acid as per (2). However, sea creatures consume the CO₂ component to build their bodies with carbon, liberating oxygen into the water.

[W35](#) reports “*It’s true that production of CaCO₃ actually drives the CO₂ pressure up, by shifting the pH of the seawater toward the acidic. But plankton communities produce more organic carbon than CaCO₃, by a factor of 4 to 10 or so (the exact number is not well known). So the CO₂ draw down by the organic carbon production outweighs the CO₂ boost from the CaCO₃ production.*”

The CaCO₃ and organic carbon together effectively act as a CO₂ sink by removing it from the atmosphere and without adversely affecting the acidity. Eventually, there will be a balance found between a higher than existing level of atmospheric CO₂ flux and an increased rate of carbon consumption by fauna and flora on land and sea. This balance will also be strongly influenced by any small changes in sea temperature.

Interim Conclusion 10

Satellite sea surface temperature readings support the relationship that exists with CO₂ levels, as presented in [Henry’s Law](#). Annual anthropogenic contribution to the natural CO₂ balance are said to be traceable through carbon 13 signature, but is a modest amount (4.5 ppm) added to the natural flux of atmospheric and oceanic CO₂ (28 ppm). Increasing CO₂ levels at sea and in the atmosphere have enhanced both the marine and terrestrial food chains. Regardless of origin, the CO₂ atmospheric concentration remains a function of the average sea temperature.

8. COROLLARIES

8.1. COROLLARY 1: ICE AGES

Paradoxically, increasing SST raises atmospheric moisture content, which increases the formation of high energy ice. (Refer Beatty, *Planets Satellites and Landforms*, 1997: ISBN 1 875401 62 8.) That is ice collecting at high altitudes which eventually results in increasing glacier activity, increasing reflection of the sun’s rays followed by a general lowering of air temperatures until an Ice Age occurs. Solar activity identified as changes in sun spot frequency also has a correlation with Earth’s rainfall and temperature patterns.

These influences likely continue until lower SST reduces humidity and the associated formation of high energy ice. However, areas of sea ice start to expand (low energy ice) due to the cold temperatures, and atmospheric CO₂ levels increase. Glaciers start to retreat due to lower humidity. The end stage of the Ice Age cycle begins when SST rise due to more vibrant submarine geological activity, accompanied by retreating sea ice sheets.

The full sequence appears to include elements of:

- 1 heightened submarine geological activity
- 2 altered solar activity
- 3 rising submarine sea temperature forming larger glaciers which result in

- 4 lower SST followed by
- 5 larger sea ice shelves and
- 6 increasing levels of atmospheric CO₂.

Ice core records suggest the time lag for this sequence of events is around 800 years.

Interim Conclusion 11

Ice Ages start when heightened submarine geological activity leads to rising oceans temperatures. Atmospheric moisture levels increase to the point where large quantities of high altitude ice form glaciers and ice sheets. Ice Ages end when geological activity subsides, but sea surface temperatures remain sufficiently high to melt large areas of sea ice.

8.2 COROLLARY 2: CRETACEOUS EXTINCTION

It is interesting to contemplate what happened when an asteroid apparently impacted the Mexican coast near Chicxulub, 65 million years ago. The explosive impact left a large crater, initiating several severe knock-on effects. It would have significantly heated the sea locally, and to a lesser extent further afield.

A second impact is postulated at [W22](#):
“But according to Dr Keller, Chicxulub was only the warm-up for a much larger impact more than a quarter of a million years later. It was this meteor which left a tell-tale layer of extraterrestrial iridium in rocks around the Earth, not the earlier one, she says. However, no-one has yet found the crater from the “final straw” impact which ended the age of reptiles in one of the largest ever mass extinctions.”



It is possible that the second impact occurred at sea leaving no visible signs of impact other than the tell tail iridium layer from the vaporised meteorite. Ocean impacts are expected to have much more severe effects on life as higher levels of suffocating atmospheric CO₂ are likely to occur.

Initially, we will assume the impact equally affected the global ocean surface. What conditions would have had to exist before a life suffocating amount of ocean CO₂ returned to the atmosphere?

[W21](#) advises: “Carbon dioxide gas is heavier than air and the gas can flow into low-lying areas; breathing air with more than 30% CO₂ can quickly induce unconsciousness and cause death.”

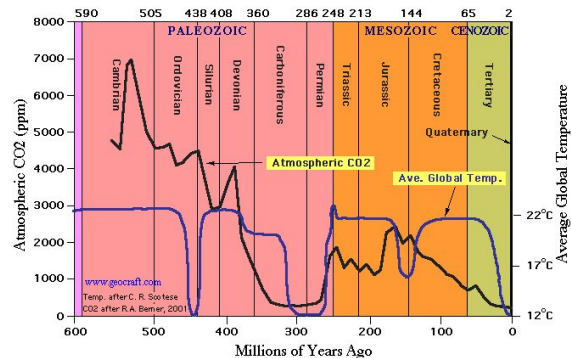
This is equivalent to an atmospheric load of 300,000 ppm.

However, physiological impacts are noticeable at 1% and become very severe at 7% CO₂. In humans and other mammals these include acidosis, dyspnea, headaches, bone loss, etc. These ailments show that species suffer life threatening physiological stress well below 30% concentration.

Toxic levels of CO₂ would not have to include the whole volume of atmosphere, either. Only the lower atmospheric strata would need to reach toxicity to cause wide spread extinction. CO₂ has a molecular weight of 44, while air is 28.84, some 1.5 times heavier. This ensures that the majority of CO₂ liberated stays close to the ground.

Reference [W43](#) shows CO₂ concentration 65 million years ago was near 1,000ppm, or 128Gt, and that limited life forms existed on Earth when concentrations were near 4,000ppm (500My).

The 500My concentration at ground level is estimated to represent a general atmospheric concentration of 1,500ppm.



This suggests an average toxicity level of 0.15% (1,500 ppm, or 190Gt) could result in 4% concentration at ground level which is expected to cause significant die-offs. Under asteroid impact conditions, it is probable that the local sea temperature climbs above 50°C which liberates CO₂ from the bicarbonate radical. See equation (3), and it is also possible for some carbonate compounds to be heated to temperatures greater than 750°C where an additional mole of CO₂ is released compared with formula (6). Limestone is reported at the Chicxulub site which increases the likelihood of the higher release value. The Chicxulub site was partly land based, and the impact crater appears to affected an area of about 175km diameter. For convenience of calculation it will be assumed it was entirely a marine event.

This makes the total exhaled volume of CO₂:

Between 50-750°C

$$(47) \quad 0.055 + 0.00073125 = 0.05573125 \text{ kg CO}_2 / \text{m}^3 \text{ sea water.}$$

Above 750°C

$$(48) \quad 0.11 + 0.00073125 = 0.11073125 \text{ kg CO}_2 / \text{m}^3 \text{ sea water.}$$

				CO ₂ Solubility							
		Temperature		Pre Impact	Post Impact	CO ₂ Dissolved		Impact	Impact	Affected	Liberated
	Salinity	Pre Impact	Post Impact	348.76	-684.60	Pre Impact	Post Impact	Diameter	Depth	Volume	CO ₂
	%	°C	°C	x10 ⁻⁶ moles/kg		kg CO ₂ /m ³			m	m	m ³ Gt
Chicxulub	3.500	5	701	3.36E-005	-1.71E-005	1.48E-003	-7.53E-004	175000	1200	2.89E+013	64
									Pre Impact Global Gt		128
									Post Impact Global Gt		193

TABLE 4

Table 4 shows post impact levels of CO₂ rising by 64Gt. However, atmospheric concentration of CO₂ was already elevated at 128Gt, so the additional load proved sufficient to exceed the 190Gt toxicity limit.

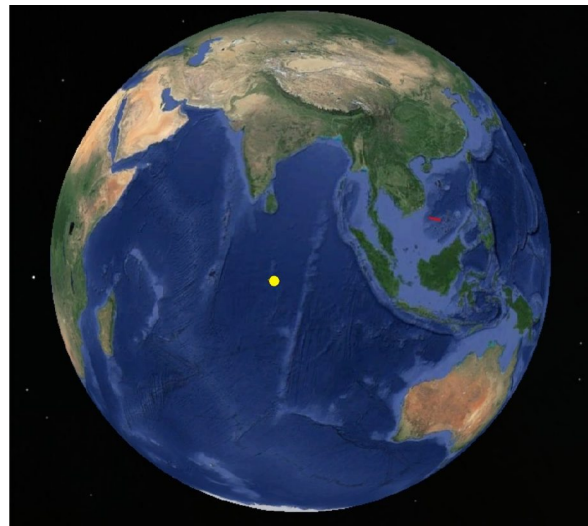
To generate the extra 64Gt over a 175km diameter, it is shown that the affected depth was 1,200m and the temperature rose above the 750°C critical level for the dissociation of CaCO₃ molecule to occur.

[W31](#) teaches 1 gigaton of TNT (Gt) is the energy equivalent of 4.184×10¹⁸ J (joules) and 1 mega tonne of TNT equals 4.184×10¹⁵ J.

NASA at [W24](#) estimates the Chicxulub impact released energy equivalent to 100 million megatons of TNT (100,000 GtTNT).

Calculation show only 4.5% of this energy would need to find its way into the ocean to cause a release of lethal volumes of CO₂ into the atmosphere.

Under current atmospheric conditions an extinction event asteroid impact with the sea would affect a cylinder of sea water of say 300 km diameter by 1.5km deep with that ocean temperature raising from 5°C to around 100 °C. This would generate a similar toxic concentration of CO₂ gas. Impact area is as shown in the Indian Ocean.



Interim Conclusion 12

In asteroid impact terms, a cylinder of sea water 1.5 km deep and 300 km diameter, with ocean temperature raising from 5 °C to above 100 °C would generate a lethal 4% concentration of CO₂ gas at ground level.

8.3. COROLLARY 3: SURVIVAL SCENARIO

Higher levels of dense CO₂ concentrate at low elevations. Low regions are most likely frequented by larger animals (easier to get around), while smaller and flighted animals could survive higher up the slopes and in tree tops. Similarly, Megapode egg layers (those that rely on rotting vegetation to provide incubation heat) could survive a short increase in suffocating levels of CO₂. Such extinction selections encourage evolution of flight, some egg layers, and small mammals putting the remaining large animals under a severe survival threat as they lapse below their critical population size.

Interim Conclusion 13

The fact that some fauna survived the Chicxulub impact suggests that the quantity of heat effectively reaching the ocean was about 4,500 Gt TNT. An asteroid impacting the ocean has the capacity to create violent short-lived marine volcanoes of CO₂, capable of dramatically increasing atmospheric levels of this gas at lower altitudes, with severe implications for life forms around the world. Large asteroids impacting the ocean are more life threatening than when hitting land.

Oceans can legitimately be considered as brisant explosives awaiting a suitable detonator.

8.4 COROLLARY 4: MAR HEATING

A similar rising CO₂ effect can occur in the atmosphere if Atlantic ocean temperature above the MAR fault line increases. This could be initiated by rising magma associated with spasmodic ridge spreading activity.

It is interesting to contemplate a super volcano opening somewhere along the MAR. In this case Atlantic Ocean temperatures could rapidly rise in a cylinder above the volcano, producing a similar result to an asteroid impact discussed under 8.2.

[W23](#) describes four earlier mass extinctions, without directly mentioning lethal CO₂ levels as a possible factor including:

“End Triassic roughly 199 million to 214 million years ago. “ - most likely caused by massive floods of lava erupting from the central Atlantic magmatic province -- an event that triggered the opening of the Atlantic Ocean.”

Permian-Triassic extinction, about 251 million years. “Many scientists suspect a comet or asteroid impact, although direct evidence has not been found. Others believe the cause was flood volcanism from the Siberian Traps and related loss of oxygen in the seas.”

Late Devonian extinction, about 364 million years ago. “Cause unknown.”

Ordovician-Silurian extinction, about 439 million years ago. “ - caused by a drop in sea levels as glaciers formed, then by rising sea levels as glaciers melted.”

Interim Conclusion 14

Any geologically recorded extinctions associated with lava and vulcanism are candidates for CO₂ poisoning as a possible cause for the extinction. This is particularly so if the vulcanism were of a submarine nature.

Also large meteorite impacts with the ocean would have a similar effect, but leave no obvious record.

9. CONCLUSIONS.

- 9.1 Asymmetric annual cycling of CO₂ in the atmosphere points to an unusually powerful driver to this system and closely connected to the Summer/Winter variation.
- 9.2 CO₂ digestion in sea water is quite sensitive to varying salt levels and particularly sensitive to changes in temperature.
- 9.3 The most significant factor in determining the depth of a thick ocean mix layer is the presence of a descending convection current formed when colder surface water sinks due to its higher density. Wind is the second significant factor.
- 9.4 Both theoretical and actual field measurements confirm the average CO₂ seasonal flux 221Gt pa and show the sea is operating within the anticipated limits for the current SST profile.
It is critical to note that the sea must heat before the level of atmospheric CO₂ can rise - not the other way around. This is important because it proves that increasing levels of anthropogenic produced CO₂ cannot cause the sea to heat initially - whether that additional CO₂ causes the global surface temperatures to rise or not.

Satellite records shows there is a recorded increase in sea surface temperatures over recent years which basic science, shows must be causative of increased levels of CO₂ in the atmosphere.

CO₂ is a heavy gas (1.5 times air) and remains in close contact with the sea surface. This permits rapid stoichiometric balancing of sea and atmospheric CO₂ during season changes.

- 9.5 The 5-7ppm CO₂ variation noticed annually at Mauna Loa should be regarded as a function describing the level of atmospheric resistance experienced when migrating large volumes of CO₂ between the northern and southern hemispheres.

Combined CO₂ southern ocean zonal influence (28 ppm) is much higher than the variations recorded at Mauna Loa (eg 386.37-380.74 = 5.6ppm). This means that CO₂ is being simultaneously added to the atmosphere at a rate of around 28 ppm during the southern winter time (northern summer).

Combined CO₂ southern ocean zonal influence (28 ppm) is much higher than the maximum annual variation recorded at Mauna Loa (386.37-380.74 = 5.6ppm). This means that CO₂ is being simultaneously added to the atmosphere at a rate of around 28 ppm during the southern winter time (northern summer).

- 9.6 The report shows the northern summer flora consumption of CO₂ is out of phase with the Mauna Loa records, but is in phase with the southern ocean surface temperatures. It is concluded that the vegetation balance is neutral

- and is a continuing system not hugely influenced by the seasonal marine variations, but is enhanced when higher levels of CO₂ exist.
- 9.7 Ocean temperature has a dominant influence on the level of carbon dioxide gas present in the atmosphere and it is unsurprising that spasmodic seismic activity will influence the average sea surface temperature. A general sea surface temperature rise of 0.46°C is sufficient to exhale of 84 ppm of CO₂ to the atmosphere since 1985.
 - 9.8 Satellite sea surface temperature readings support the relationship that exists with CO₂ levels, as presented in Henry's Law. Annual anthropogenic contribution to the natural CO₂ balance are said to be traceable through carbon 13 signature, but is a modest amount (4.5 ppm) added to the natural flux of atmospheric and oceanic CO₂ (28 ppm). Increasing CO₂ levels at sea and in the atmosphere have enhanced both the marine and terrestrial food chains. Regardless of origin, the CO₂ atmospheric concentration remains a function of the average sea temperature.
 - 9.9 Ice Ages start when heightened submarine geological activity leads to rising oceans temperatures. Atmospheric moisture levels increase to the point where large quantities of high altitude ice form glaciers and ice sheets. Ice Ages end when geological activity subsides, but sea surface temperatures remain sufficiently high to melt large areas of sea ice.
 - 9.10 In asteroid impact terms, a cylinder of sea water 1.5 km deep and 300 km diameter, with ocean temperature raising from 5 °C to above 100 °C would generate a lethal 4% concentration of CO₂
 - 9.11 The fact that some fauna survived the Chicxulub impact suggests that the quantity of heat effectively reaching the ocean was about 4,500 Gt TNT. An asteroid impacting the ocean has the capacity to create violent short-lived marine volcanoes of CO₂, capable of dramatically increasing atmospheric levels of this gas at lower altitudes, with severe implications for life forms around the world. Large asteroids impacting the ocean are more life threatening than when hitting land.
Oceans can legitimately be considered as brisant explosives awaiting a suitable detonator.
 - 9.12 Any geologically recorded extinctions associated with lava and vulcanism are candidates for CO₂ poisoning as a possible cause for the extinction. This is particularly so if the vulcanism were of a submarine nature. Also large meteorite impacts with the ocean would have a similar effect, but leave no obvious record.

10. ACKNOWLEDGEMENT

Several members of the ICs International <http://www.bosmin.com/ICS/ics.pdf> group of resources consultants as well as personal relatives and internet contacts have reviewed draft components of this report. The resulting suggestions are greatly appreciated and I hope the end result stimulates more exploratory discussion.

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