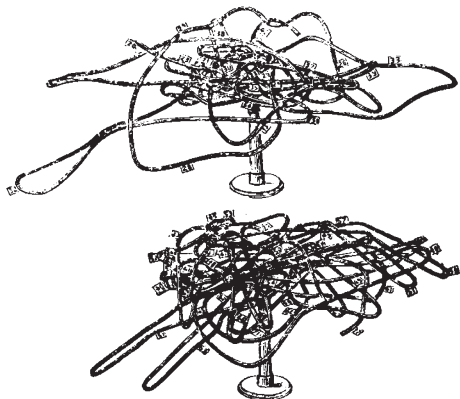


100 years ago

A MODEL OF AN EARTHQUAKE



Prof. Sekiya describes a very curious and remarkable model he has made to exhibit the manner in which a point on the earth's surface moves during an earthquake. The motion which is recorded at an earthquake observatory is a prolonged series of twists and wriggles of the most complicated kind, so that the path pursued by a point on the surface of the soil has been aptly compared to the form taken by a long hank of string when loosely ravelled together and thrown down in a confused heap. From *Nature* 37, 297; 26 January 1888.

involved in virus-cell attachment.

Equally fascinating would be some involvement in the cell-mediated immune response of the host. One possibility would be that it might interfere with the induction of cell-mediated immunity, another (less advantageous to the virus) that it induces a cytolytic T-cell response that does not require the involvement of host class I molecules. Both these possibilities seem unlikely, because healthy humans respond to HCMV infection with a typical (host) class I MHC-restricted virus-specific cytolytic T-cell response.

Unfortunately, not enough of the basic questions have been answered yet for us to make a sufficiently informed guess about the meaning of the intriguing result of Beck and Barrell. But at the very least, if the gene encodes a protein with a useful viral function, we have an opportunity to study an example of a viral glycoprotein hijacked from host cells and converted through evolution to its own purposes. □

1. Beck, S. & Barrell, B.G. *Nature* 331, 269–272 (1988).
2. Ho, M. *Archs Virol.* 55, 1–24 (1977).
3. Sonnabend, J., Witkin, S.S. & Purtilo, D.T. *J. Am. med. Ass.* 249, 2370–2374 (1984).
4. Zinkernagel, R.M. & Doherty, P.C. *Adv. Immun.* 27, 51–177 (1979).
5. Grundy, J.E., McKeating, J.A. & Griffiths, P.D. *J. gen. Virol.* 68, 777–784 (1987).
6. McKeating, J.A., Griffiths, P.D. & Grundy, J.E. *J. gen. Virol.* 68, 785–797 (1987).
7. Grundy, J.E., McKeating, J.A., Ward, P.J., Sanderson, A.R. & Griffiths, P.D. *J. gen. Virol.* 68, 793–803 (1987).
8. Bjorkman, P.J. *et al. Nature* 329, 506–512 (1987).
9. Bjorkman, P.J. *et al. Nature* 329, 512–518 (1987).
10. Allen, H., Fraser, J., Flyer, D., Calvin, S. & Flavell, R. *Proc. natn. Acad. Sci. U.S.A.* 83, 7497–7501 (1986).

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Geochemistry

Archaean carbon and gold

E.G. Nisbet and T.K. Kyser

THE origin and distribution of CO₂-rich fluids deep in the Earth's continental crust is a taxing problem not only for metamorphic petrologists, but also for seismologists, igneous petrologists, those modelling planetary degassing and the history of the atmosphere and biosphere, those exploring for gold, and even the occasional astrophysicist. The debate centres on the question of whether these fluids are ultimately derived from reservoirs fixed near the Earth's surface (carbonate sediments, organic carbon and seawater-derived hydrothermal carbonates), originate from the mantle, or represent recycled mixtures of both. Groves *et al.*, on page 254 of this issue¹, conclude from the carbon-isotope composition of Archaean (older than 2.5 × 10⁹ yr) gold deposits that sea water alone is not the source.

In Archaean gold lode deposits, such as those in Canada and Australia, gold mineralization occurs with sulphides, often in quartz veins, which are enveloped by or associated with rocks rich in carbonate. The gold may have been carried into place by reduced sulphur complexes in low-salinity H₂O–CO₂ fluids. Where did these fluids come from? One hypothesis is that the fluids were derived by metamorphic degassing of crustal rocks²; alternatively, they may have magmatic sources³.

One facet of the debate about the origin of these fluids hinges on the interpretation of the carbon-isotope composition of the fluids. This is measured by the δ¹³C parameter, which gives the difference in the measured ratio ¹³C/¹²C from that in a seawater-derived standard, normalized to that standard. Variations occur because of fractionation, and negative values show that the sample is slightly depleted in ¹³C. For carbonates derived from sea water, δ¹³C ≈ 0‰. For reduced carbon δ¹³C ranges from –10‰ to –45‰, and the mean crustal value for oxidized and reduced carbon is –5‰ to –7‰.

Sea water

Most carbonates from gold mines appear to have δ¹³C values between –2‰ and –4‰. If the CO₂ that is now present in gold mines came from metamorphic decarbonation of seawater-derived carbonate, the δ¹³C value of the carbonate associated with the gold would have a small positive value. It is unlikely, therefore, that sea water alone is the source. On the other hand, the δ¹³C values of average crust (–6 ± 1‰), magmatic (about –5‰) and mantle (about –2‰ to –5‰) rocks

are generally comparable⁴, and none of these can be considered a unique source for the carbonate associated with the lode gold.

Burrows *et al.* suggest⁵ that the source for CO₂ in many carbonates associated with gold lode deposits was originally magmatic, originating from outgassing of melts intruded into the crust, because of the similarity in the range of δ¹³C values of gold-related carbonate to typical magmatic values. Groves *et al.* summarize¹ much of the available δ¹³C information — the scatter is large, ranging from 0‰ to –10‰ for gold deposits, considering the subtlety of the arguments based on the data — and conclude that sea water alone could not have been the sole source of carbon for the CO₂ in the metamorphic fluids. Some carbon, at least, must have been derived from a source with a negative δ¹³C value such as the mantle.

Degassing

In contrast to those who have proposed a direct magmatic source³, however, Groves *et al.* argue¹ that some CO₂ was introduced into the rock via major fault zones which were fed with CO₂ by metamorphic degassing. But in the spirit of compromise, they suggest that the original source of this CO₂ was in the mantle. This is interesting in the light of the arguments of those who have suggested that massive degassing of carbon from the mantle is taking place.

More generally, the debate illustrates our lack of knowledge of the Earth's carbon cycle. Carbon is degassed at within-plate volcanoes and at mid-ocean ridges, but most carbonate is added to new ocean floor by hydrothermal alteration. This CO₂, together with any organic matter added to the ocean floor, is carried down the subduction zones and acts as a source for the CO₂ degassed by volcanoes and perhaps even for diamonds. Javoy *et al.* argue⁴ that oceanic basalts also contain carbon with very low δ¹³C values (down to –25‰) and further that the δ¹³C value of CO₂ outgassed in magma erupted above subduction zones varies substantially with depth of origin and distance from the trench. The 'mantle' source of the sub-continental carbon could be variable and originate from subduction zones.

It is also possible that biological effects alter the δ¹³C value of 'mantle' carbon. Biological carbon is very light (δ¹³C ~ –30‰) and work in Archaean high-grade terrains has shown that rocks originally formed on the surface within the biosphere often constitute part of the deep continental crust. Perhaps this may be a