NATURE

100 YEARS AGO

The native arithmetic of Murray Island, Torres Strait, is described by the Rev. A. E. Hunt in the latest *Journal* (New Series, vol. I Nos. 1 and 2) of the Anthropological Institute. The only native numerals are netat (one) and neis (two). Higher numbers would be described either by reduplication, as neis netat, literally, two-one for three; neis-i-neis, or two-two for four, &c., or by reference to some part of the body. By the latter method a total of thirty-one could be counted. The counting commenced at the little finger of the left-hand, thence counting the digits, wrist, elbow, armpit, shoulder, hollow above the clavicle, thorax and thence in reverse order down the right arm, ending with little finger or right hand. This gives twenty-one. The toes are then resorted to, and these give ten more. Beyond this number the term gaire (many) would be used. English numerals are now in general use in the Islands.

From *Nature* 5 January 1899.

50 YEARS AGO

Fertilized mouse ova have been cultivated *in vitro*, and their development filmed, by Friedrich-Freska and Kuhl, who used as medium a clot of guinea pig plasma and mouse embryo extract containing segments of Fallopian tube. Like Chang, I have been working on ovum culture with a view to transplantation of ova. Chang has used rabbits, with serum as a culture medium; I have chosen to use mice, as more readily available, and because (like most domestic animals) they have naked eggs. Seeking a medium readily prepared in large quantities, I have tried saline hen-egg extracts. The procedure adopted revealed an unanticipated difference between the viabilities of two-cell and later tubal stages; eight-cell ova survived and developed in culture, whereas two-cell ova did not. ... A few became blastocysts either completely separated from the zona, or spherical and still half-enclosed in the split and distended membrane. ... A physiological difference between two-cell and eight-cell stages seems clearly established; the reason for the difference remains obscure. The result recalls a similar one of Chang's, namely, survival of morulae, but not two-cell ova, when transplanted into the rabbit uterus, though both survived when cultivated in serum.

From *Nature* 1 January 1949.

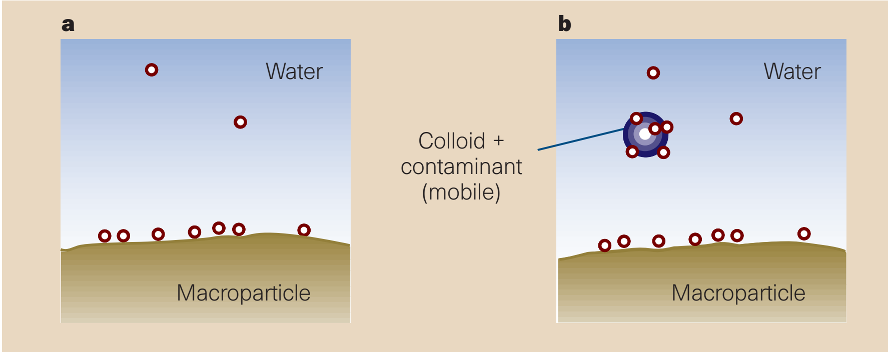

Figure 2 **Comparison of generalized two- and three-phase groundwater systems.** a, **Two-phase;** b, **three-phase. The third phase in** b **is a colloid or microparticle, shown here with contaminant molecules sorbed to it, thus making them mobile. Colloidal material is usually chemically similar to the stationary macroparticle phase.**

bations or changes in flow velocity from pumping, and through *in situ* precipitation of supersaturated mineral phases. Colloids are removed from the aqueous phase by deposition on stationary macroparticles; it is the efficiency of deposition that regulates the facilitation of contaminant transport[6].

Kersting and colleagues' analysis[1] of colloids isolated from pumped ground water clearly identified the source of the Pu as a single underground nuclear test site, the test well and detonation site being 1.3 km apart. The elimination of other detonation cavities and contamination as the source of Pu makes it evident that the Pu has been transported through the ground water by some process.

As delineated by Ryan and Elimelech[5], however, three conditions must be met for defensible evidence that colloids have transported contaminants: first, colloids must be present; second, contaminants must associate with them; and third, the colloid–contaminant combination must move through the aquifer. The results of Kersting *et al.* qualitatively meet the first two conditions. But, as the authors point out, the possibility of sampling artefacts meant that they could not quantify some of the parameters needed for supporting the detailed assessment of colloid-facilitated Pu transport in their study. That is, the third condition has not been rigorously met. Nevertheless, their work clearly shows that a low-solubility contaminant travelled some way from the source, perhaps at or near the local groundwater flow velocity ($1-80\ \mathrm{m\ yr^{-1}}$).

Has the Gordian knot been cut? No, I do not think so, although a good slice has been taken out of it. The fundamental difficulty remains the gap between field observations and expectations based on bench-scale experiments and theory. For example, according to classical filtration theory, colloid transport should be relatively limited (tens of metres[7] or less under typical subsurface conditions). Advances in incorporating[8] macroparticle chemical heterogeneity and site blockage into models have helped to narrow the gap, but it nonetheless remains wide.

The trouble with most field studies is that the systems are difficult to manipulate, and are often too large and heterogeneous to characterize accurately. There is a great need to develop meso-scale experimental systems (several metres to more than ten metres) for the careful evaluation of the effects of system heterogeneity on colloid transport and the testing of methods for scaling up from the bench to the field.

Given that the work by Kersting *et al.* shows that Pu may be transported considerable distances through groundwater systems, can one conclude that the colloidal transport of actinides provides a significant exposure pathway from nuclear testing and waste sites? Not really. The very properties of compounds that make them good candidates for colloid-facilitated transport — low solubility and high particle reactivity — limit the amount of contaminant that can be transported: colloids are both the means and the bottleneck. But we need to know more. T. H. Huxley[9] had it that "It is the customary fate of new truths to begin as heresies and to end as superstitions [dogma]". In its evolution from heresy to dogma, colloid-facilitated contaminant transport has become a perceived truth, widely recognized, but rarely understood in detail. □

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