Selenium Medical Geology

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The naturally occurring element selenium (Se) is essential to human and other animal health in trace amounts but is harmful in excess. Of all the elements, Se has one of the narrowest ranges between dietary deficiency (< 40 µg day^{-1}) and toxic levels (> 400 µg day^{-1}) [WHO (1996)] making it necessary to carefully control intakes by humans and other animals. Although Se is released to the environment from its use in the ceramic, pigment, photocopier and pharmaceutical industries, it is geology that exerts a fundamental control on the distribution of the element in the soils on which we grow the crops and animals that form the human food chain. Since diet is the most important source of Se in humans, the Se-status of crops, animals and therefore populations varies markedly around the world as a result of different geological conditions. Se concentrations in most rock types are very low (< 0.1 mg kg^{-1}), however, very high concentrations (≤ 600 mg kg^{-1}) have been reported in some phosphatic rocks, coals, black shales and mineralised areas [Plant *et al.*(2004)]. In animals and humans, selenium forms a vital constituent of the biologically important enzyme glutathione peroxidase (GSH-Px) and to date approximately 25 essential selenoprotiens have been identified [Rayman (2005)]. Selenium deficiency, which is widespread in many parts of the world, has been implicated in white muscle disease in animals and in a host of conditions in humans including cancer, a heart disease called Keshan Disease which occurs in China, Kashin-Beck disease, a bone and joint disorder found in Russia and China, immune system function, reproduction and thyroid function. In contrast, selenium toxicity, or selenosis, occurs rarely and has been reported in areas underlain by black shales and coals in the USA, China and Venezuela, and causes alkali disease in animals, and vomiting, diarrhoea, hair (*photo 1*) and nail loss and nervous disorders in humans [Fordyce (2005)]. Work into the causes of Keshan Disease has proved that Se deficiency allows viruses to mutate. This is of increasing importance as recent evidence suggests that new strains of the influenza virus and avian flu are emerging in Se-deficient regions and that Se supplementation protects against these viruses [Beck *et al.* (2003)]. Recent work has also shown better health outcomes in HIV-AIDS patients given Se supplements [Kupka *et al.* (2004)], which is significant given the link between Se-deficient environments and areas where the disease is prevalent in Africa and Asia. Looking to the future, understanding the biogeochemical controls on the distribution and mobility of environmental Se is key to the assessment of Se-related health risks. Although overt clinical symptoms of Se toxicity and deficiency are rarely reported, the possible sub-clinical effects are at present poorly understood and should not be under estimated as medical science continues to uncover new essential functions for this biologically important element.

Photo 1: Hair loss as a result of selenium toxicity (China).
Photo 1 : Chute de cheveux due à la toxicité du sélénium (Chine).

References: **M.A. Beck, O.A. Levander and J. Handy (2003)** – Selenium deficiency and viral infection 1. Journal of Nutrition, vol. 133, p.1463S-1467S. **F.M. Fordyce (2005)** – Chapter 15: Selenium deficiency and toxicity in the Environment. In: O. Selinus (editor). Essentials of Medical Geology. Academic Press, London, p. 373-415. **R. Kupka, G.I. Msamanga, D. Spiegelman, S. Morris, F. Mugusi, D.J. Hunter and W.W. Fawzi (2004)** – Selenium status is associated with accelerated HIV disease progression among HIV-1-infected pregnant women in Tanzania. Journal of Nutrition, vol. 134, no. 10, p. 2556-2560. **J.A. Plant, D. Kinniburgh, P. Smedley, F.M. Fordyce and B. Klinck (2004)** – Chapter 9.02: Arsenic and Selenium. In: B. Sherwood Lollar (editor). Environmental Geochemistry. H.D. Holland and K.K. Turekain (exec. editors). Treatise on Geochemistry Series, vol. 9, Elsevier, Amsterdam. p. 17-66. **M. Rayman (2005)** – Selenium in cancer prevention: a review of the evidence and mechanism of action. Proceedings of the Nutrition Society, vol. 64, p. 527-542. **World Health Organisation (1996)** – Trace elements in human nutrition and health. World Health Organisation, Geneva.

D'un point de vue chronique, des troubles gastro-intestinaux, des atteintes dentaires ou encore des anomalies neurologiques ont pu être observés. Aucun effet cancérogène n'a été établi. Dans ce contexte, la réglementation française et européenne impose une concentration maximale en sélénium pour l'eau distribuée de 10 µg/L.

Les propriétés chimiques du sélénium sont proches de celles du soufre. Il est souvent associé au fer ou à l'uranium. En présence de fer, il est susceptible de co-précipiter pour former de la ferrosélite $FeSe_2$. Les formes les plus oxydées peuvent être adsorbées sur des oxydes ferriques.

La présence de minéraux de sélénium est souvent associée à la présence de gisements d'uranium. Une telle association se rencontre dans des grès, sables ou conglomérats à restes de plantes correspondant à d'anciens dépôts fluviatiles. Le sélénium est généralement