

GEOCHEMISTRY OF CAESIUM AND FLUORIDE IN CORNWALL AND DEVON: EVIDENCE FROM TELLUSSW

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The TellusSW geochemical survey provides comprehensive data on concentration of Cs in stream sediments, soils and water as well as fluoride in waters. Devon and Cornwall are one of the most enriched areas in Cs in Western Europe. This reflects Cs concentration in fine-grained granite of west Dartmoor, late stage Li-F rich granites in St Austell, Tregonning and Dartmoor bodies, which are also enriched in Ta, as well as concentration in reworking of granitic and acid volcanic material in early Permian sediments. Fluoride water highs are sourced in these Li-F rich granites, younger F vein mineralisation as well as forming a broad high in mid-Devon, spatially related to the occurrence of lamprophyres and the late Permian Littleham Mudstone Formation

Caesium, although high in granites, is particularly enriched in the aureoles of these granites, notably in meta-basic rocks. These enrichments are evidence for the passage of Cs-rich fluids through the aureoles. Fluoride in water does not in general exceed World Health Organisation guidelines, with the exception of limited mineralised areas in west Cornwall and on Lundy Island.

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INTRODUCTION

Caesium and Fluorine are known to be enriched in some late stage granites in SW England (Bowler, 1958; Fuge and Power, 1969; Fuge *et al.*, 1992), as is caesium in early Permian sediments (Merefield 1981). Merefield (1986) further proposed that caesium could be used as an indicator of the source and diagenesis of Permo-Triassic sediments. There are limited data on the distribution of the elements in the surface environment of SW England; Fuge and Andrews (1988) showed that F is enriched in soils and waters of the china clay areas of Cornwall and Devon as did Fuge *et al.* (1992) for Cs in the St Austell area.

The limited data on the spatial distribution of the two elements was significantly supplemented in 2014 with the release of the TellusSW geochemical data set (TellusSW, 2014). The aim of this contribution is to discuss the spatial distribution of these elements from these new data and examine their distribution in relation to the evolution of late stage granites, their associated mineralisation and their distribution within Permo-Triassic sediments using mainly soil, stream sediment and water samples.

The two elements are chosen for discussion because of their association with lithium-rich granites. Tantalum and niobium are also known to be enriched in these granites but their distribution in TellusSW stream sediments has been previously discussed in Moon (2015), so is not covered in detail here. Also Ta and Nb are largely contained in relatively insoluble minerals (Scott *et al.*, 1998) and would not be expected to disperse far from their source in the secondary environment. No fluorine analyses are available for soils and stream sediments due to cost considerations detailed below but available fluoride in water is discussed. This will not reflect all fluorine in rock (Boyle, 1982) but will reflect some of its distribution as demonstrated by Fuge and Andrews (1988).

General geochemistry

Caesium is the heaviest of the stable alkali metals and has a large ionic radius, rendering it incompatible with most rock forming minerals. It can make limited substitution for K in K-feldspar and mica. Caesium forms few minerals of which it is an essential component. These minerals mainly result from late-stage volatile activity, particularly in lithium-caesium-tantalum pegmatites (London, 2005, 2008). The most important Cs mineral is pollucite. Although natural caesium is not recorded as a pollutant, its artificial isotopes ¹³⁴Cs and ¹³⁷Cs, derived from nuclear fission, are. Their presence from nuclear bombs tests as well as the Chernobyl and Fukushima incidents has led to very detailed studies of Cs mobility (Qin *et al.*, 2012). These studies showed that Cs is fixed in interlayer sites in clay minerals in the fine grained portion of mineral soils but Cs is much more mobile in organic peaty soils (Staunton *et al.*, 2002).

Fluorine is the lightest of the halogen elements and forms a number of common minerals such as fluorite and topaz as well as substituting for OH in apatite, muscovite and a range of other micas and amphiboles (Wedepohl, 1978). Fluorine is released as fluoride during weathering but its solubility is limited by the formation of fluorite, so its concentration is often inversely proportional to that of Ca²⁺ (Ander *et al.*, 2005).

Caesium has not been routinely determined in geochemical surveys due to its low abundance (upper crust average ~ 2.6 ppm) and relatively high detection limit (often 4 ppm by XRF before 1995). However improved XRF methodology as well as routine adoption of ICP-MS methodology has led to its determination in multi-element suites. Fluorine is also underrepresented in multi-element databases as it is not possible to determine background level F in soils or stream sediments by XRF or ICP-MS. Most routine determinations are undertaken using an ion selective electrode after sample fusion,