



Serpentinites and the High Incidence of Breast Cancer in Marin County, CA - Pilot Study

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Serpentinites

Serpentinization

Olivine + Water = Serpentine + Brucite

Serpentine ($Mg_3Si_2O_5(OH)_4$)



Other Minerals: Talc, brucite, chlorite, actinolite, tremolite, magnetite, chromite

Background

Extensive deposits of serpentinites (metamorphosed ultramafic rocks) are present in Marin County and western California as discontinuous outcrops due to ocean crust emplacement and transform movement along the San Andreas Fault. Serpentinites contain elevated concentrations of toxic and carcinogenic elements including Cr, Ni, Fe, Mg, Mn, Co, Cd, V and Hg and weather (undergo chemical and physical alteration) to produce groundwater, soils (referred to as serpentine soils), sediments and dust also containing elevated levels of these elements. Concentration of these elements in Marin rocks and soil exceed carcinogen regulations set forth by OSHA, IARC, and CGIH. In Marin County as well as other serpentinite localities around the world, the extent of exposure through inhalation, digestion, and dermal contact with water and dust and the role of these carcinogenic elements in breast cancer etiology have never been explored.

Hypothesis

In this study, we hypothesize that the increased prevalence of breast cancer in Marin County is due in part to exposures in areas with serpentinite rock, soils formed from these rocks, and related waters due to the abundance and availability of toxic and carcinogenic elements (Cr, Ni, Fe, Mg, Mn, Co, Cd, V, and Hg) inherent of these rocks, soils, and waters.

Objectives/Aims

The long-term aim is to address the community's concern whether the increased prevalence of breast cancer in Marin County is due in part to exposure to areas with serpentinites and related materials (solids and solutions). The objectives to be completed in this pilot study include:

1. Obtaining geologic and chemical data for Marin and creating a modifiable GIS database
2. Assessing the concentration, geochemical availability, and pathways of elemental exposure and uptake of Cr, Ni, Fe, Mg, Mn, Co, Cd, V, and Hg related to serpentinites, related sediments, serpentine soils, dust, and related water
3. Initiating the collection of breast cancer incidence and mortality databases with Marin specific, individual-level breast cancer risk factor data and residency information.

Methods

This project is at the scientific forefront of examining the potential role of non-anthropogenic carcinogenic elements in the initiation of breast cancer. A combination of field and laboratory studies as well as community involvement will begin to provide the foundation for evaluating the nature of these carcinogens and their potential association with breast cancer in Marin County. Mineralogical and geochemical analyses including optical microscopy, whole rock compositions, electron microprobe mineral compositions, and Raman spectroscopy will be performed on the collected samples in order to identify the specific minerals and phases contributing the noted carcinogenic elements. Whole rock/soil chemical analyses, chemical extraction experiments, and water and dust analyses will be completed at Stanford and Dartmouth and will be integrated into a GIS format to examine the spatial distribution and the potential pathways of bioaccumulation. This geologic and chemical data set will then be used in a future CRC proposal to examine potential correlations in breast cancer incidence (data collection initiated in this study) in Marin County.

Impact on Breast Cancer

Ultimately this study will begin to unravel whether certain carcinogenic elements derived from serpentinites and related material are potential factors that should be considered in future ecologic and/or etiology studies of breast cancer in Marin County as well as other geographic areas in the world having seemingly unexplainable high incidences and mortality rates of breast cancer. Additionally, this study might provide insight for epidemiological and biospecimen evaluation with regards to a specific element which might be highly concentrated, bioavailable, and breast cancer specific. If serpentinite-related elements do pose a potential hazard, the synergy created between Marin Breast Cancer Watch, scientists, and the community will be able to work collaboratively to formulate remediation strategies and government involvement.

Serpentine Soils

- High concentrations of Cr, Ni, Co, Mn, Fe
- Low Ca/Mg quotients
- Deficient in plant nutrients
- Characteristic flora



Elemental Concentration Ranges in the Franciscan Complex of California

Element	Concentration Range (mg kg ⁻¹)	
	Serpentinites	Serpentine Soils
Cadmium	0.1	<10
Cobalt	97-215	99-238
Chromium	580-2,280	1,725-4,760
Iron	30,000-110,000	58,000-121,000
Magnesium	80,000-154,000	52,400-84,200
Manganese	155-1,860	1,375-1,990
Mercury	Unavailable	270-670
Nickel	2,037-3,960	2,290-3,910
Vanadium	Unavailable	14-136

Health Effects Related to Excess Concentrations of Elements in Serpentinites

Element	Effect of Excess
Cadmium	Carcinogen, elevated in breast cancers, reduction of effective filtration capacity on glomerulus (renal toxicity)
Cobalt	Carcinogen
Chromium	Carcinogen, toxic as Cr(VI), contact dermatitis
Iron	Haemochromatosis
Magnesium	Potential competitive inhibitor of calcium
Manganese	Manganism, psychiatric disorders
Mercury	Damage to central nervous system
Nickel	Carcinogen, elevated in breast cancers, contact dermatitis (mostly in women)
Vanadium	Unknown except at high doses

Major Serpentine and Serpentine Soil Localities

