GEOLOGICAL HAZARD NOTICE

From The California Geological Survey

CGS GeoHazard Notice 2009-001

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SMECTITE CLAY DEPOSITS - SIERRA NEVADA FOOTHILLS

The California Geological Survey (CGS) recognizes that preliminary information generated in an on-going geologic investigation has provided sufficient data to warrant a *Geologic Hazard Notice*. This notice is directed to engineering and building departments of counties and cities whose jurisdictions encompass land within the following defined region: from the eastern margin of the Sacramento/San Joaquin Valleys to the eastern extent of historic hydraulic gold mines of the Sierra Nevada, between the Feather and Stanislaus River watersheds.

Hazard Description

Exposed in patchy, often isolated, localities within the defined region is a particular geologic unit composed of varying mixtures of durable sand and an unusual form of expansive smectite clay. Despite geologic field observations, geotechnical site investigations, and laboratory soil testing performed by experienced professionals, the recognition of these deposits and the behavior of the expansive clay component has proven problematical. As a consequence, a significant number of structures, mostly residential, located in several foothill community developments have experienced severe foundation cracking and other significant structural damage resulting from unanticipated latent ground swelling. In other locations, landslides and other slope failures are associated with this geologic unit. Damage to structures due to expansive clay has been documented in Sacramento and Placer counties, and slope instability in this geologic horizon is known to have occurred in Placer, Nevada, Sierra, and Plumas counties. This geologic unit is also likely to be exposed in Butte, Yuba, El Dorado, Amador, Calaveras and Tuolumne counties (see attached map).

Soil Recognition and Testing Issues

Following are the basic issues related to the recognition, testing, and behavior of the smectite-bearing unit.

- Geologic mapping has historically portrayed the hazardous clayey materials as part of, or as the “upper” member of the Ione Formation. The Ione Formation is well known for producing non-expansive kaolinite clay for the ceramic industry. The expansive clay deposits stratigraphically lie above the commercial kaolinitic units, but they have rarely been differentiated on geologic maps. Geologic investigations to date have demonstrated that the unusual form of these expansive clay deposits has caused geologists to variably assign them to geologic units besides the Ione Formation, including the Valley Springs, Mehrten, Riverbank, and Turlock Lake formations, as well as Quaternary surficial deposits. Such confusion suggests that the geologic map units listed above should be considered suspect and receive careful scrutiny when they appear on geologic maps and soil logs included in geotechnical reports.
- Field identification of the unit and its expansive clay fraction can be difficult. This is because the clay occurs mainly in the form of sand-sized nodules, or clasts that have thin coatings of silica, iron oxide, and other cementing agents (see photos). These physical characteristics often lead geologists, engineering geologists, and geotechnical engineers to misinterpret the material as being composed largely of durable sand and granular constituents.

- Laboratory testing using conventional ASTM laboratory methods to obtain index engineering properties of the soil has been unreliable. ASTM grain size (sieve and hydrometer) tests appear unable to reliably detect the true proportion of potentially expansive clay during the relatively short time it takes to process soil samples in the laboratory. The cementing agents coating the clay inhibit the dispersion and expansive behavior of the clay until the cements are broken down by earthwork or dissolve following surface exposure. The latter process can take years to fully develop. This same phenomenon causes the ASTM Atterberg limits, Plasticity Index (PI), and the Expansive Index (EI) tests to indicate much lower plasticity and expansion potential than what actually occurs in the soil over time.
- Compaction specifications determined in the laboratory using ASTM methods often prove to be invalid. This is because the laboratory generated "optimum moisture" specifications only apply to the initial granular form of the subject clay and not its behavior once a significant amount of smectite is released from the encapsulating cementing agents. Absorption of water by the stabilized clay granules during the laboratory testing can be a small fraction of the soil's actual latent water absorption capacity. Likewise, when using the material for engineered fill, even careful moisture conditioning and compaction of the subject soil using recommended methods for expansive fill placement leaves enormous latent expansion potential. One local soil engineer found that up to 15% latent expansion potential remained in engineered fill following very careful moisture conditioning, compaction, and placement of fill material derived from the subject clayey soil.

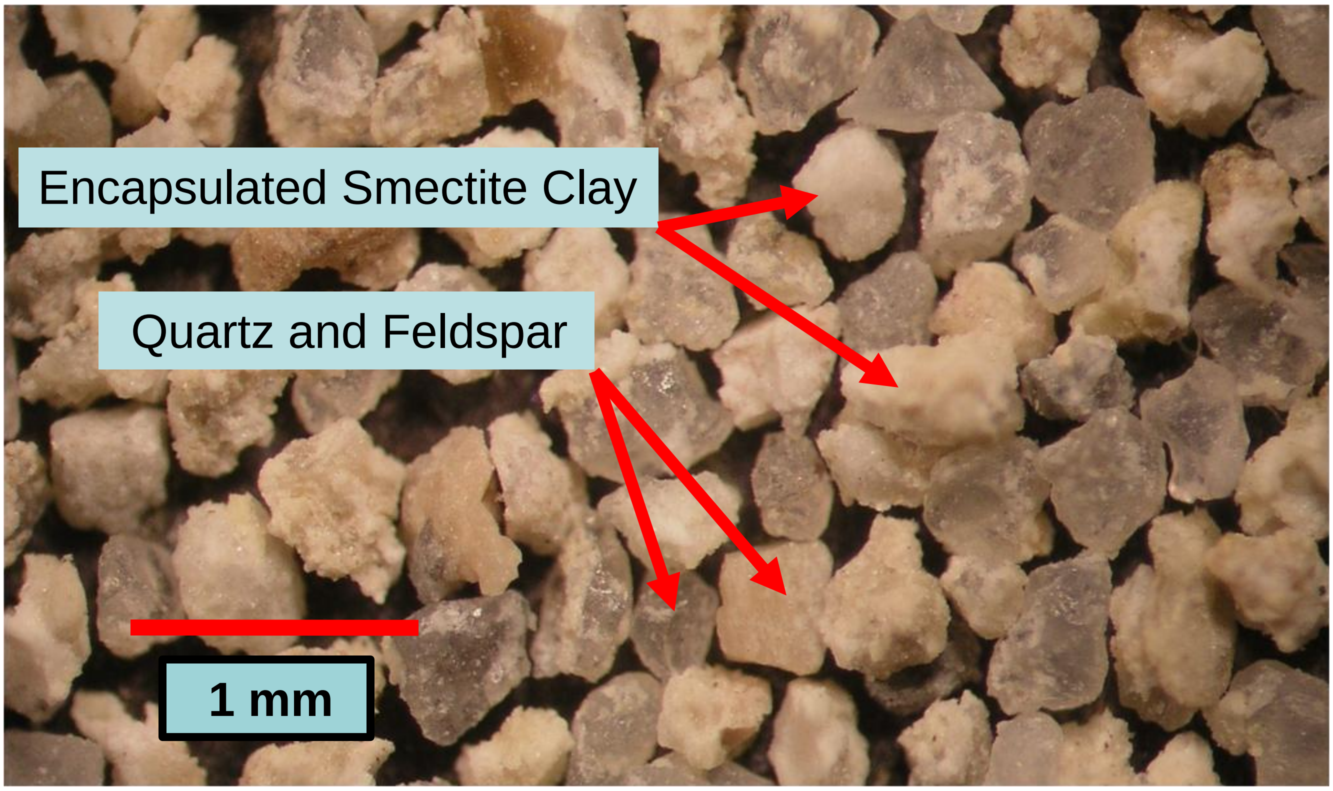
Supplemental Soil Test Methods

It is apparent that conventional ASTM soil tests often fail to provide results that reflect the true engineering properties of the smectite clay deposits under consideration. Some local consultants have been successful using petrographic techniques, including optical microscope and X-Ray Diffraction (XRD), to identify and characterize the smectite clay content of these problem soils. However, until a set of consistently reliable tests have been identified, permitting agencies should work closely with developers to ensure that contracted geotechnical firms are aware of the form and characteristic behavior of the smectite clay component.

Ongoing Work

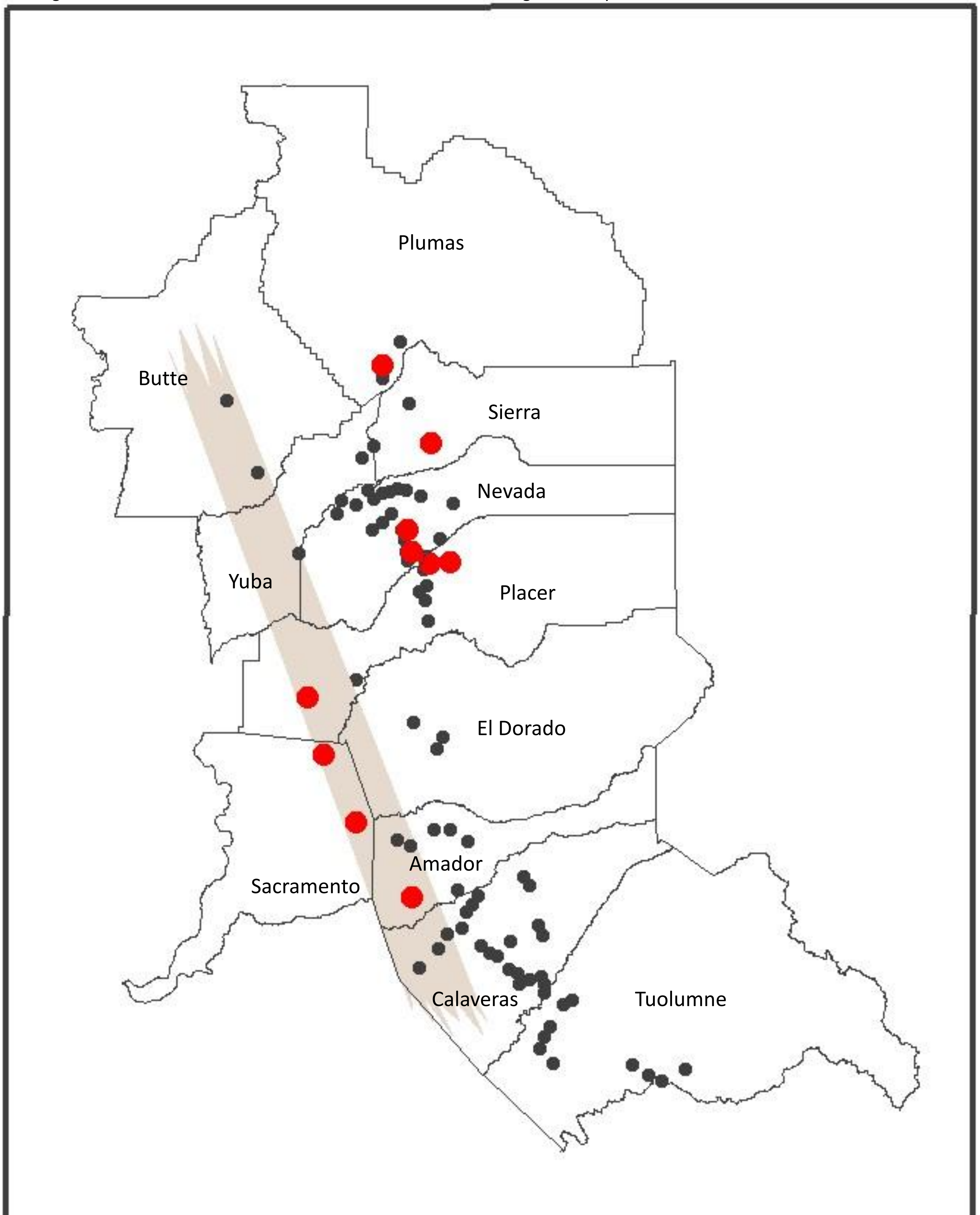
An informal group of engineers and geologists from consulting, academic and state government organizations has been working to better understand the distribution and characteristics of this smectite clay unit. Geologic maps that more accurately depict the areal distribution of the problematic clay materials are in progress. Several foundation design strategies have been developed to accommodate the expansion potential of these soils, and if recognized beforehand, it appears that related landslide-prone areas may be avoided or remediated prior to development.

For more information contact CGS Senior Engineering Geologists Tim McCrink (916) 324-2549 or Ralph Loyd (916) 322-9207. CGS may issue *Revised Notices* on these smectite clay occurrences as more information becomes available.



Typical fine-grained sand of the subject smectite-bearing geologic unit. Sample collected from northeastern Sacramento County. Microscope photo by James L. Wood.

Same fine-grained sand as above after adding moisture and hand rolling the sample. Photo by James L. Wood.



County map showing (1) sites where documented ground swelling and/or slope failure (red dots) have occurred in smectitic sand deposits of the subject geologic unit; (2) the lower Sierra Nevada foothill belt (tan colored) where deposits of the unit are most likely to be encountered; and (3)notable historic hydraulic pits (black dots) where the unit is commonly exposed immediately above the main-channel gravel deposits of the Ancient Tertiary Rivers of the Sierra Nevada.