about 2000 ft to the west, but it was not accurately located. For 2000 ft, in urban Hayward, the fault zone is in an alluviated plain that breaks through the hills; individual faults have not been traced across this plain.

Most stream courses are sharply offset to the north wherever they cross the fault zone. San Lorenzo Creek, a main west-flowing stream, cuts through the hills at Hayward, turns sharply northwestward, and follows the fault for more than a mile before resuming its westerly course. Offsets of other, lesser stream courses do not exceed a few hundred feet and, for most streams, are less than 50 ft.

There is stratigraphic, as well as geomorphic, evidence of horizontal movements. Southeast of Hayward, rocks of Upper Jurassic and early Pleistocene ages on the west side of the fault have apparently been shifted about 1200 ft northwestward. Nearly 4 mi of relative northward horizontal displacement of the west side of the fault may be inferred from the position of outcrops of the Knoxville formation of Upper Jurassic age; however, other interpretations are possible. Recurrent horizontal displacements clearly began in late Pleistocene time or earlier and have continued to the present.

The abrupt and rather straight, although dissected, hill front suggests vertical displacements on an essentially vertical fault plane. As shown by wells drilled on the Bay plain within a few hundred feet of the hill base, the steep bedrock front continues far below the Bay plain. In places, 650 ft or more of unconsolidated marine and alluvial deposits are banked against it. Total vertical displacement may have been far more than 1000 ft. Most of the vertical displacement happened so long ago that the original scarp has retreated and streams have cut away the rapids or waterfalls, which must once have existed at fault crossings. Thus, displacements of the last hundreds or thousands of years seem to have been largely horizontal.

The narrow Hayward fault zone is near the western edge of a broad faulted belt extending more than a mile back into the hills. In the hills are two long faults subparallel to the hill front, linked to each other and to the Hayward fault by short east-west transverse faults. The two long faults seem to be high-angle reverse faults with largely dip-slip displacements, the southwest sides having moved relatively up and northeastward. These faults, despite probable displacement of many hundreds of feet, are largely without topographic expression and seem to have been inactive for thousands of years.

Viewed broadly, the entire fault belt is well regarded as a single great fault zone. It is understandable that the term "Hayward fault" has gradually come to be applied to the entire mile-wide belt. This application has led to the widespread notion that the entire belt is equally active seismically and offers equal earthquake risk. But only a narrow strip near the hill front is clearly an active fault zone in which earth movements may reasonably be anticipated; most of the faulted belt in the hills offers much less short-term engineering risk. Particularly for this reason, it seems desirable to follow the original usage of the term "Hayward fault," and to apply it only to the narrow zone of definitely active faulting.

G. D. Robinson

U.S. Geological Survey
Denver Federal Center, Denver, Colorado

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Kaolin of Early Eocene Age in North Dakota

Light-colored kaolinitic clays that comprise the lower part of the Golden Valley formation cap many of the divides and underlie several small synclines in southwestern North Dakota. The stratigraphic relationships and flora of the Golden Valley formation as a whole indicate an early to middle Eocene age, and the lower kaolinitic portion is almost certainly earliest Eocene, the time equivalent of at least a part of the Wasatch formation.

The kaolin must have once blanketed most of southwestern North Dakota and may have an even wider extent. A line circumscribing the outermost outcrops encloses an area of more than 6000 mi^2, and none of these outcrops suggests an approach to the original depositional limit of the clays.

Over their large outcrop area, the clays of the Golden Valley formation are remarkably uniform. Most exposures are 15 to 25 ft thick with the extreme range 5 to 45 ft. In gross aspect, most outcrops consist of three major units: (1) A basal unit of light purplish gray shaly clay, slightly carbonaceous and locally with numerous fossil plants; this clay is typically silty, but a few local lenses are plastic and silt-free. (2) A middle unit (missing in a few localities) of tough white sandy fire clay, mottled and stained yellow orange by iron oxides; the oxides seem to come from small limonite pellets that are the weathered relics of siderite pellets. (3) An upper unit of purplish gray clay similar to the basal unit; a thin impure lignite or dark carbonaceous clay commonly overlies the upper purplish gray clay and forms the top of the outcrops.

Locally the lower part of the formation grades laterally into a white crossbedded sand with a kaolin binder. The sand consists chiefly of angular to subangular quartz, as much as 20 percent angular calcite, 2 to 5 percent feldspar, muscovite, and about 3 percent heavy minerals, including garnet, tourmaline, kyanite, and others. The calcite is in discrete particles and does not appear to be a cement. Its origin is unknown. None of the minerals including the feldspars show signs of weathering since deposition.

Laboratory tests indicate that the clay beds consist chiefly of kaolinite (with minor amounts of halloysite or endellite), quartz, detrital mica, and some amorphous silica. The kaolinite is a fine-grained aggregate and shows no wormlike crystals or "books." Minor constituents consist of siderite pellets in the white fire clays, secondary iron oxides, and tiny veinlets of iron-montmorillonite(?). The montmorillonite is secondary and appears to be associated with the iron oxides.

With the possible exception of the calcite, all the major constituents are of sedimentary origin and have undergone little or no change since deposition. The kaolin was transported as kaolin and laid down in a continuous blanket over many thousand square miles. This suggests deposition in a large shallow freshwater lake, an idea supported by the nature of the flora and the presence of lignite lenses in the clay beds. The shallowness enabled streams to build natural levees and carry sand for some distance into the lake.

Such a large blanket of relatively pure kaolin must indicate a source area (to the west) that was subject to deep intensive weathering but little erosion at the close of the Paleocene epoch. This is about the time of formation of the bauxite and kaolin deposits of the Gulf Coastal Plain, and possibly also of the kaolin deposits in the Pacific coastal states. The end of the Paleocene epoch seems to have been a time of intense and rapid weathering over much of the country.

WILLIAM E. BENSON

U.S. Geological Survey
Denver Federal Center, Denver, Colorado

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Spirodiscus Ehrenberg Identified as *Ophiocytium* Nägeli

EHRENBERG'S work, the *Infusionsthierchen* (*1*), is an important landmark in the history of protozoology and a minor one in the history of bacteriology. In this work, Ehrenberg set up a family Vibrionia, with five genera, *Vibrio, Bacterium, Spirillum, Spirochaeta,* and *Spirodiscus.* Among these genera, the first four include most of the bacteria as known at the time. *Spirodiscus,* on the other hand, is clearly not a bacterium. It appears to have remained unidentified until the present.

A single species, *Spirodiscus fulvus,* was listed. It had been named without description in an earlier publication (*2*). In the original description (*1*) the main points were as follows:

> Dreissigste Gattung: Scheibenspirale. Spirodiscus. Spirodisque.
>
> Character: Animalia e familia Vibrioniorum, divisione spontanea imperfecta (et obliqua ?) in catenam filiformem s. cochleam rigidam disciformem accrescens. . . .
>
> 99. Spirodiscus fulvus, gelbbraune Scheibenspirale. Tafel V. Fig. xiv.
>
> Sp. cochlea lenticulari, obsolete articulata, fulva, 100-mam lineae partem fere lata. . . .

The organism had been found at Syrjanofskoi, in the Altai Mountains, in fresh water among confervas.

Some of the points of this description, as "imperfect spontaneous division," appear to be without objective meaning. The figure to which the description refers consists of four little drawings whose appearance and size may be understood by the statement that they look like pods of bur clover, *Medicago,* and are colored with brown and green stripes. The characters to which anything identified as *Spirodiscus* must conform are these: it is a freshwater organism with cylindrical pigmented cells more or less compactly coiled and having an overall diameter of about 20 μ, that is, 1/100 of a line.

Here it is pointed out that the organism known as *Ophiocytium parvulum* (Perty) Braun conforms to the characters stated. No other organism is known to do so. It is accordingly maintained that *Spirodiscus fulvus* is *Ophiocytium parvulum.*

HERBERT F. COPELAND

Sacramento Junior College
Sacramento, California

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Basaltic Magma at Hawaii Is Saturated in Silica

MODERN knowledge of the geology of Hawaiian volcanoes has established that most of the lava of all the separate volcanoes has been erupted in a stage of primitive shield-building activity. A small volume has been added to many of the volcanoes in a declining phase of the primitive shield-building stage, and a very small amount has been erupted at a few volcanoes in a stage of decadent activity. The petrography of the rocks of the primitive shields is monotonously similar through all exposed depths within a given volcano and among all the different volcanoes. The rock types present are picritic basalt, olivine basalt, and basalt, with olivine-hypersthene basalt important in a few volcanoes.

The differences in mineralogy of the shield-forming rocks are entirely in the amount of olivine and hypersthene present and, apparently, can have been caused by the concentration or removal of phenocrysts of olivine and hypersthene. Rocks formed in the declining phase of the shield-building activity commonly contain phenocrysts of augite and calcic plagioclase but, otherwise, are similar to those making the bulk of the shield.

A most important difference does not appear in the gross mineralogy and, commonly, is not even apparent in microscopic mineralogy. This is the fact that the abundant olivine basalt of the primitive shield is chemically a silica-saturated rock, whereas the apparently similar olivine basalt erupted during the declining phase is chemically undersaturated in silica. Deficiency of silica is indicated by normative olivine and sometimes nepheline in the rocks of the Hawaiian province. The significant abundance or scarcity of silica can be compared straightforwardly if the percentage of normative olivine and nepheline is not used, but rather a figure is computed from the chemical analysis that states the percentage of silica needed to form saturated normative minerals. The computed abundance or scarcity of silica has been compared with