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Clastic Dikes

Jack Kume

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CLASTIC DIKES

A thesis
Presented to
The Faculty of the Department of Geology
University of North Dakota

In Partial Fulfillment
of the Requirements for the Degree
Bachelor of Science of Geology

by
Jack Kume
May 20, 1958
CLASTIC DIKES

Jack Kume

ABSTRACT

Clastic dikes are tabular bodies of clastic material transecting the structure and bedding of the enclosing rock. The dikes may be either straight and parallel or irregular, sinuous, or zigzag, and they may be either closely spaced or distantly spaced. The thickness of the dikes ranges from a mere film to 10 feet, but commonly, they are 2-3 feet thick. The dike material has invaded the containing rocks along a fissure either through a surface opening or a subsurface opening. The fissures have originated from earthquakes, folding, faulting, submarine slumping, or shrinkage of the containing rock. Fissures are filled by sedimentation, injection, and replacement. Clastic dikes are significant for their association with ore bodies in certain areas, as a top and bottom criterion, as a record for seismic activity, and as geomorphic features.

A classification of clastic dikes is proposed based upon the mode and location of fissure filling. The dikes may be classified into two groups: dikes formed by the filling of an open surface fissure, and dikes formed by the filling of a subsurface fissure.
<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>ABSTRACT</td>
<td>1</td>
</tr>
<tr>
<td>LIST OF TABLES</td>
<td>iv</td>
</tr>
<tr>
<td>LIST OF ILLUSTRATIONS</td>
<td>iv</td>
</tr>
<tr>
<td>INTRODUCTION</td>
<td>1</td>
</tr>
<tr>
<td>DESCRIPTION OF CLASTIC DIKES</td>
<td>2</td>
</tr>
<tr>
<td>Appearance</td>
<td>2</td>
</tr>
<tr>
<td>Related Sandstone Bodies</td>
<td>7</td>
</tr>
<tr>
<td>Mineralogy</td>
<td>10</td>
</tr>
<tr>
<td>Petrography</td>
<td>12</td>
</tr>
<tr>
<td>ORIGIN OF THE FISSURES</td>
<td>13</td>
</tr>
<tr>
<td>Earthquakes</td>
<td>13</td>
</tr>
<tr>
<td>Faulting and Folding</td>
<td>14</td>
</tr>
<tr>
<td>Submarine Slumping</td>
<td>15</td>
</tr>
<tr>
<td>Shrinkage</td>
<td>16</td>
</tr>
<tr>
<td>MODES OF FISSURE FILLING</td>
<td>18</td>
</tr>
<tr>
<td>Filling of a Surface Fissure</td>
<td>18</td>
</tr>
<tr>
<td>Filling of a Subsurface Fissure</td>
<td>21</td>
</tr>
<tr>
<td>CLASSIFICATION OF CLASTIC DIKES</td>
<td>24</td>
</tr>
<tr>
<td>Classification</td>
<td>26</td>
</tr>
<tr>
<td>SIGNIFICANCE OF CLASTIC DIKES</td>
<td>26</td>
</tr>
<tr>
<td>Economic Value</td>
<td>26</td>
</tr>
<tr>
<td>Top And Bottom Criteria</td>
<td>27</td>
</tr>
<tr>
<td>Record of Seismic Activity</td>
<td>27</td>
</tr>
<tr>
<td>Geomorphic Feature</td>
<td>28</td>
</tr>
<tr>
<td>SUMMARY AND CONCLUSIONS</td>
<td>28</td>
</tr>
<tr>
<td>REFERENCES CITED</td>
<td>31</td>
</tr>
</tbody>
</table>
LIST OF TABLES

Table                                                                 Page
1. Clastic Dikes                                                   30

LIST OF ILLUSTRATIONS

Figure                                                                   Page
1. Sandstone Intrusion Exposed in a Sea Cliff..                        3
2. Shale Beds Dip Away From Both Sides of the Intrusion                 3
3. Sketches of Clastic Dikes                                            4
4. Earthquake Fissure Filled With Intruded Sand                       9
5. Sandstone Dike Cropping Out of the Surface                           9
6. Biotite of Sandstone Dike, Crushed Edgewise By the Vertical Movement of the Sand 12
7. Structural Effects of Slumping in Penecontemporaneous Material      17
8. Clastic Dike Formed By the Filling of a Fissure From Above             20
INTRODUCTION

Strangways (1821), according to Newsom (1903, p. 254), seems to be the first to describe dikes of clastic material. He described a number of clay dikes near the village of Great Pulcova, Russia.

The injection or intrusion of clastic material into sedimentary and other rocks has been of interest to geologists since this phenomena was first regarded as somewhat of an anomaly. Dana (1830) referred to clastic dikes as "pseudo-dikes" of sandstone. On the other hand, Shrock (1948) states that clastic dikes are analogous to igneous dikes.

Clastic dikes, synonymous with the term sandstone dikes (which limits the size of the clastic dike material), are tabular bodies of clastic material transecting the structure and bedding of the enclosing rock. The dike is composed of extraneous material that has invaded the containing rocks along a crack either from below or above (Howell, 1957). The term "pebble dike" has been applied to clastic dikes by Farmin (1934). He was using this term to distinguish the size of the clastic dike material.

Clastic dikes have been described many times, but only a few, if any, complete reviews of this literature have been published. The knowledge of such a review would be of value in the understanding, analysis, and interpretation of clastic dikes. This paper is not a complete review of the literature on clastic dikes; however, an attempt is made to present a
short, general review of the subject.

The writer wishes to thank Mr. F. D. Holland, Jr. for his continued interest and aid in the paper.

DESCRIPTION OF CLASTIC DIKES

Appearance

Clastic dikes are nearly vertical wall-like masses of asphalt, silt, clay, gravel, bituminized and unbituminized sands, sandstone, conglomerate, coal, and limestone (Newsom, 1903, p. 268). Most dikes are nearly vertical, some dikes dip at angles near 60°, while others may dip at angles less than 45°, but this is rare. The dikes may be either straight and parallel, or irregular, sinuous, or zigzagged, and they may be closely spaced or distantly spaced (Fig. 3) (Lupher, 1944, p. 1445). The position of the dikes has been determined by the joints in which they are contained. The joints may be straight, offset, or zigzag, both vertically and horizontally.

Some of the clastic dikes appear to end or pinch out before reaching the surface, while others may end in a downward course. The dikes may combine with other dikes or separate into several branches (Diller, 1890, p. 424). According to Lupher (1944, p. 1442), less than half of the dikes in the Columbia Basin, Washington, occur as single units, while most of the dikes are arranged in compound or multiple units (Fig. 3). Park (1933, p. 46) points out that
Fig. 1. Sandstone Intrusion exposed in a sea cliff near Santa Cruz, California. Pleistocene gravels and sand rest unconformable upon the underlying diatomaceous shales. Dike has a wavy banded structure. (adapted from Newsom, 1903, p. 247).

Fig. 2. Shale beds dip away from both sides of the intrusion. Clastic dike is near Graves Creek, California. (Modified after Newsom, 1903, p. 235, Fig. 2)
A. Control of dip of foreset bedding by the dip of fissure.

B. Compound dike
   a. Trough-like stratification formed by periodic infall of sand and pebbles.
   b. Parallelism of stratification and fissure walls on segment of low dip.

C. Compound dike displaced by a horizontal fault and fault cut by later dikes; possible sequence of dikes is shown by numbers.

D. Sand filled cavity formed by melting ice block; with a feeder dike.

Fig. 3. Sketches of clastic dike sections to illustrate structures and materials. (adapted from sketches by Lupher, 1944, p. 1444).
many dikes split into two to five branches which may divide again or unite with another branch of the same or another dike system.

The thickness of the dikes range from a mere film to 18 feet, but commonly they are two to three feet thick (Price, 1933, p. 1527). The dikes may extend several yards or several miles in length. One dike was reported to extend continuously for nine and a half miles (Diller, 1890, p. 411).

The most favorable condition for the origin of clastic dikes, is the presence of unconsolidated sedimentary material overlain by a hardened cracked stratum (Lahee, 1952, p. 84). Commonly, the dike material has the same composition as that of the underlying or overlying stratum.

Farmin (1934, p. 366) reported that dikes have trans­ected with equal efficiency rocks of quartzite, shale, limestone, dolomite, and lava. Vitanage (1954, p. 493) observed clastic dikes in the brecciated zones of granite and schist.

Parker (1933, p. 46) noticed vertical grooves and stiae on the walls of a few dikes. This evidence seems to show a differential movement following lithification, between the dike material and the contained rocks. Mc Callie (1903, p. 199) reports that the contact of the dikes usually showed a very irregular or rough surface made up of numerous shallow depressions and elevations. Occasionally, the walls were smooth and polished with slickensides. Shrock (1948, p. 212) points out that contorted wall material and an in-
ternal and marginal dike structure may indicate that the dike was formed by a fissure filling under pressure. Newson (1903, p. 235) observed shale beds dipping away from both sides of the clastic dike intrusion (Fig. 2). Jenkins (1925b, p. 238) observed clastic dike material that was partly composed of angular fragments of basaltic wall rock.

Grace (1952, p. 20) pointed out that some of the dikes exhibit some bedding which is poorly developed and not parallel to the regional dip. Lupher (1944, p. 1447) reported that stratification is very common in clastic dikes which have been formed at the surface by deposition into an open fissure. He described the stratification as one in which the layers or laminae dip at angles near 30° from the horizontal. This resembles forset beds without the usual top-set and bottomset beds. The bedding extends from the footwall of the fissure obliquely downward and across the hanging wall (Fig. 3).

Newson (1903, p. 251) observed bituminized sandstone dikes in the Santa Cruz area, California. The dikes were so heavily charged with bitumin that the clastic dike material was firmly cemented. Underlying the transected shales is a bituminized sandstone which probably was the source of the intruded sand, as many of the dikes are directly connected with this sandstone.

Cross (1894, p. 227) observed clastic dikes that were
composed of a fine, well rounded sandstone that had a sac-charoidal texture. The dikes were indurated into a dense, hard quartzite.

While attending the Miami University field camp near Dubois, Wyoming, during August, 1957, writer observed several clastic dikes in the Mississipian Madison formation. These dikes located at NW 1/4, NE 1/4, Sec. 1, R108W, T41N, in upper Warm Spring Creek area of the Wind River Basin. The dikes were composed of a red limestone conglomerate with a sand matrix. The dikes transected a massive dolomite, and their contact with the dolomite was uneven and rugged. The dikes are vertical and trend N80°W.

Fossils have been found in some of the clastic dikes. Russell (1927, p. 405) identified fish scales and some fish bone fragments in several dikes in the Black Hills area. Similar scales and fish bone fragments can be found in the nearby Mowry shale. The source of the dike material was thereby established. McCallie (1903, p. 201) noticed abundant fossils in all of the larger dikes in an area near Chattahoochee River near Columbus, Georgia. The fossil shells were mostly bivalves. Vitanage (1954, p. 497) reports that Monroe (1932) noted that pelecypod valves in sandstone dikes in Texas, were oriented parallel to the containing walls.

**Related Sandstone Bodies**

Associated with clastic dikes are sandstone sills which
according to Pettijohn (1957, p. 191) are similar in all respects, but they are parallel instead of discordant with the bedding. Although the sills may be difficult to distinguish from a sandstone interbed, the sills are not stratified or cross-bedded, and they may locally cross the bedding due to its injected origin. Pettijohn (1957, p. 191) states that,

"No doubt some of the sandstone beds are themselves sills of a sort injected at the mud-water interface by the under flow of a dense slurry. The similarity in microtexture of these beds and true dikes and sills is a substantial argument for their origin from a turbidity under flow."

Fuller (1912, p. 57) noticed "sand sloughs" and "sand blows" associated with clastic dikes in the New Madrid Earthquake area in Tennessee and Missouri. He described "sand sloughs" as a sand filled linear depressions, three to five feet below the general level of the bottomlands. The "sand blows" are low patches of white sand which dot the alluvial surface of certain parts of the earthquake area. During 1811-1813 earth waves and fissures were formed in this area. The fissures provided the passageways for the extruded sand. Powerful jets of water filled with sand issued out of the fissures, and after the flow ceased, the openings were left full of sand (Fig. 4).

Clastic plugs have been associated with clastic dikes by Parker (1938, p. 38) in the Cimarron Valley, New Mexico. Upon the basis of shape the cylindrical clastic masses were classified as plugs, whereas, the tabular clastic masses
Fig. 4. Earthquake fissure filled with intruded sand. New Madrid Earthquake area near Charleston, Missouri. The dike is about 3 feet thick. (after Fuller, 1912, p. 52).

Fig. 5. Sandstone dike cropping out of the surface. (Modified after Diller, 1890, p. 416). Dike is 5 feet thick.
were classified as dikes.

Mineralogy

Anderson (1944, p. 256) points out that mineralogic studies definitely can eliminate certain stratigraphic formations as the source of clastic dike material. A comparison is usually made with that of the lithology of the formation higher and lower than the formation through which the dike transects. A formation which exhibits similar mineralogy is more likely to be the source of the clastic material than a formation which is different.

The composition of clastic dikes varies in different areas. Farmin (1934, p. 336) found the matrices between the pebbles of limestone and quartz to be composed of fragments of igneous rocks and jasperoid, carbonate mud of finely broken fragments of limestone and dolomite, shale, quartzite, and porphyry. The fragments of rock were broken from the formations underlying the clastic dikes and the limestone formation transected by the dikes. These fragments were injected upward by fluids of magmatic origin.

Vitanage (1954, p. 498) reported that in the sandstone dikes of the South Platte area the chief detrital constituent in the twelve thin sections studied was quartz. The bulk of the quartz grains are rounded and stain free. A considerable number of the grains show secondary growth. The cement is mainly chlorite and limonite with a small amount of secondary silica. The low percentage of less
than two percent feldspar seems to indicate that the sediments were subjected to thorough weathering. Other accessory minerals include chert, biotite, muscovite, zircon, and tourmaline. Subangular rock fragments suggest that there was two sources for the sediments. Most of the rock fragments are identical with the Pikes Peak granite of Precambrian age.

Kruger (1938, p. 305) identified clastic dikes of glacial origin. The dike material was composed of an unsorted argillaceous till. "The till showed a heterogeneous assortment of materials derived from diverse rock types" (Kruger, 138, p. 306).

Price (1933, p. 1529) analyzed several samples taken from a clastic dike in the Redstone coal (Pennsylvanian) of West Virginia and Pennsylvania. The dikes were composed mostly of clay with gypsum forming a coating on the clay particles. Other identified minerals were muscovite, quartz, pyrite, and chlorite.

Clastic dikes observed by Newsom (1903, p. 231) were composed of a fine grained quartz sand. It was cemented by calcium carbonate, and some dikes contained calcite veinlets and inclusions of diatomaceous shale.

The dikes described by Mc Callie (1903, p. 201) were composed of a light gray, fine grained quartz sandstone which contains considerable muscovite and some clay. A yellowish or brown color which was due to the presence of
iron oxide, was noticed. The quartz grains were angular and didn't show signs of much wear.

Facker (1941, p. 550) reported that the composition of the clastic dikes was similar to the detritus of the nearby basaltic flows. The sandy and shaley filling in Keweenawan lava were composed of plagioclase, augite, magnetite, ilmenite, quartz, basalt fragments, leucoxene, hematite, limonite, chlorite, kaolinite, epidote, and calcite.

Petrography

Vitanage (1954, p. 497) prepared twelve thin sections and found seven of these to be oriented in three planes perpendicular to one another.

"Several thin sections showed preferred orientation of the longer axis of the elongated grains.... Generally, the elongated quartz grains have their longer axis parallel to the walls or to the layering. The flakes of biotite and muscovite also show some parallelism in their arrangement" (Vitanage, 1954, p. 497).

Fig. 6. Biotite of sandstone dike, crushed edgewise by the vertical movement of the sand. Scales of biotite are less than a half a millimeter in length. (adapted from Diller, 1890, p. 426).
Mc Callie (1933, p. 201) noticed that the muscovite scales showed no indication of having been crushed or subjected to pressure since their original deposition in the dikes. Diller (1890, p. 433) points out that if the scales of mica and other lamellar fragments are standing on edge or are parallel to the fissure walls, this seems to indicate that the sand of the dike had at one time moved upward in filling the fissure. If the sand had been deposited by the wind or water and dropped into the fissure under the influence of gravity alone, the mica flakes would generally be oriented in a horizontal position or parallel to the planes of stratification.

ORIGIN OF THE FISSURES

Earthquakes

Fissuring was common and widespread during the New Madrid Earthquake of 1811-1813. Fuller (1912, p. 47) reports that, "Among the most vivid accounts is that of Le Sieur who says that the earth rolled in waves several feet high with visible depressions between the swells, finally bursting and leaving parallel fissures extending in a north-south direction for distances of as great as five miles in some cases." The fissures were due to the downfaulting of narrow strips of earth. At the present time the fissures exposed at the surface are either open or filled. They are filled with sand extruded when the fissures were
formed or filled with debris which has fallen in subsequently.

Lupher (1944, p. 1452) states that the origin of fissures must be based upon more tangible criteria. He believes:

"There are no tangible criteria for identifying ancient earthquake fissures. This interpretation depends largely upon the reasoning that earthquake fissures have formed in recent times, that sand and water have been erupted through them and therefore they offer a simple and perhaps logical means for accounting for both dikes and fissures."

Tectonic movements or earthquakes have disturbed the packing of the grains in the graywacke beds observed by Wood (1958, p. 97). The disturbance of the grains caused the injection of the coarser and more water laden layers into the finer, less mobile, grained layers.

Faulting and folding

Fissures are associated with compressional fault zones and folded beds. Newsom (1903, p. 251) noticed that the cracks and fissures were formed primarily by elevation of the coast line of California. Uplift has been more or less regular in the region since the end of the Miocene.

Vitanage (1954, p. 493) associated clastic dikes with brecciated zones in granites and schists. The dikes trend northwest or coincide with the structure axis of the Front Range in Colorado. This seems to indicate that the fissures were formed during a period of major faulting or orogenic movements. The slickensides and the direction of the many cross-faults suggest that the dikes have been subjected to...
shear movements. Harms (1958, abs., p. 14) has dated the clastic dikes in the southern Front Range as Laramide, because of the dike's constant association with Laramide faults. He states that the "dikes are oriented parallel to planes perpendicular to the axis of least compression during thrusting."

Clastic dikes were reported by Anderson (1944, p. 254) as associated with slip planes of a fault zone. The movement continued after the dikes were formed as there is evidence of faulting within the dikes. Slickensides and down drag of the fissure walls show the direction of the fault movement. The coal on either side of the clay dike is ordinarily sheared with one set of the shear planes paralleling the dike, and one set dipping in the opposite direction to form a set of conjugate shears. The clay dikes are generally wider than the fissure opening in which the dike material entered. This suggests that contraction must have taken place in the coal.

Submarine slumping

Fissures may be formed in areas of submarine slumping when unconsolidated sediments are put in motion on the ocean floor. Fairbridge (1946, p. 87) points out that sandstone dikes that are common in regions with slumping, appear to be associated with the contemporaneous movements. He believes that the "lessons of submarine slumping do not appear to have been utilized much in the past to the ad-
vantage which they might." Slumping is the result of sediments moving under the influence of gravity, and it has been found that unconsolidated sediments have been set in motion down even a gentle slope of two or three degrees. Slumping is inevitable with normal sediments at a slope of five degrees. Slumping should, therefore, take place into geosynclines and even gently subsiding basins (Fig. 7). Shrinkage

Fissures may be caused by contraction or shrinkage of the containing rocks when lithification or solidification took place. Fackler (1941, p. 555) believes that fissures can caused by thermal contraction. He observed a haphazard and irregular fissure pattern which didn't indicate a response to any regional stresses or to movements of the igneous flow while it was cooling. The cracks and fissures decrease in size with depth. Thermal contraction of the igneous mass could account for these fissures.

Fractures can result from shrinkage in the invaded material. According to Shrock (1948, p. 213), shrinkage, apparently, is a common phenomenon in coal and mud. Newsom (1903, p. 268) points out that coals are favorable for clay and sand intrusions, due to the fact, when vegetable matter undergoes changes necessary to convert it to coal, the beds become fissured. Sand and clay lying above and below the coal are then squeezed into the newly formed cracks.
Fig. 7. Structural effects of slumping in penecontemporaneous material. (adapted from Fairbridge, 1946, p. 85).
MODES OF FISSURE FILLING

Clastic dikes may be formed contemporaneously with the origin of the fissure, crack, or crevice, or subsequently formed. The dikes can easily be distinguished from the containing rocks since the dikes are markedly different in origin and physical properties. The question arises, Whence came the dike material? It must have come from above or below the containing rocks. Clastic dikes may have formed by the filling of a fissure exposed at the surface or by the filling of a fissure by subsurface injection.

Filling of a surface fissure

Detritus may drift into and finally fill a fissure in the bedrock at the surface of the ground or under water (Fig. 8) (Lahee, 1952, p. 83). The material may be washed, blown, or otherwise brought into the fissure opening. The material is likely to exhibit a wide range in composition and texture. The fissure walls should be sharp and not deformed as they usually are if the material was injected into the fissure by force (Shrock, 1948, p. 217). The wall, however, may exhibit signs of erosion and weathering due to its surface exposure. Crevice fillings were reported by Fackler (1941, p. 550). He noticed that the dike material was derived from erosion of basalt and basalt tuffs. The filling were washed into the cracks and were older than the basalt flow lying above the filling. Jenkins (1925b, p. 244) observed dikes that were filled from surface material or mat-
erial that came from the dike walls. Water was probably present when the material filled the fissure.

If the fissure were filled from above by loose sand and other material deposited by the wind or water under the influence of gravity, the more or less foliated minerals and particles such as mica would lie generally horizontal or parallel to the plane of stratification (Diller, 1890, p. 432). The dikes would be transversely stratified (Fig. 8).

Lupher (1944, p. 144a) reported surface filled fissures on the evidence that the dike material was similar to the sediments above the dikes. He proposed four methods of surface fillings, (1) sediments were brought by streams, lake currents, and waves moving across the tops of the open fissures, (2) sediments that have collapsed from the fissure walls and poured in from unconsolidated surface layers, (3) sediments carried by underground currents, and (4) windborne sediments. He believes that the fissures were usually filled by two or more processes operating either together or alternately. Lupher (1944, p. 1449) states that commonly, it is "impossible to determine from the dike material and structures alone whether streams, lake currents, waves, or wind brought the sediment into the fissure." In the Columbia Basin area the emphasis is given to moving water as the agent of deposition. This is based upon the following reasons: the abundance of gravel and coarse sand in the sorted or stratified dike sediments, the lach of eolian sedi-
iments in the proglacial beds, and the common origin of dikes in overlying current-bedded layers which are composed of material like that in the dike. Stratification was very common in these surface filled fissures.

Fig. 8. Clastic dike formed by the filling of a fissure from above. (modified after Lahee, 1952, p. 82).

An examination by Lupher (1944, p. 1445) showed little suggestion that the dikes he observed were formed by squeezing of plastic layers into an open fissure as proposed by Jenkins (1925). Lupher stated that "experiments would require that the same layers occur in reverse order in opposite halves of the dike." Instead there are compound dikes of two, four, or more layers of different composition and different thickness (Fig. 3).

Kruger (1938, p. 305) observed clastic dikes in New Hampshire that were of glacial origin. He reported that a
water saturated clay till existed beneath the glacier during melting, and due to the ice movements, the clay till became injected into the open fractures.

**Filling of a subsurface fissure**

Clastic dikes may be formed by injection from below the strata transected with water, petroleum, or petroleum residues under hydrostatic pressure, pressure of the overlying beds, gases, or combinations of several causes (Newsom, 1903, p. 268). The most favorable condition for the origin of this type of clastic dikes is the presence of unconsolidated sedimentary material overlain by a hardened cracked stratum (Lahee, 1952, p. 84).

If it can be shown that the scales of mica stand on edge vertically, parallel to the sides of the dike with banding parallel to the walls, Diller (1890, p. 433) believes that the sand has been forced into the fissure. This doesn't indicate direction of flow. The vertical position of the mica scales and banding may also be caused, as in metamorphic rocks, by a movement in the mass as a result of lateral compression after the fissures were filled with loose sand.

If the fissures failed to reach the surface or are offset in a manner that would not allow surface filling, only injection of the sand could have taken place.

Vitanage (1954, p. 499) observed sharp, uneroded dike walls, vertical bedding, and curved structures in narrow clastic dikes of the South Platte area, Colorado. This
seemed to indicate that the dike material was forced into the fissures and not washed into the fissures by a slow process. Due to the fact that the surrounding rocks are granite and gneiss, there is no underground source for the dike material. It is therefore believed that the weight of the overlying beds forced the unconsolidated sand into the fissures.

The vertical bedding and curved structures may be explained by the experiments that Jenkins (1925) made with clays under pressure. Vitanage (1954, p. 497) reports Jenkins (1925) as saying:

"A very fluid clay on top or between layers, got up greater speed than the others in being thus squeezed into a crack and broke out through the stiffer clays, advancing or squirting to a point beyond. Bunches of powdered material were put inside of balls of clay, and then placed in the press. All were injected by the press into the crack between the wooden blocks and came out finally in layered form, not intermixed at all, but in separate and distinct sheets, some of them being quite thin indeed."

Farmin (1934, p. 364) reported clastic dikes as associated with a magmatic solution, gas, or mud origin. The dike material was made up of "pebbles" that were very mobile as indicated by the tiny "sills" that extend into the wall rock from the main body of "pebbles." The fragments were broken from the underlying rocks and were injected under a pressure capable of forcing apart the walls of the invaded ground. Farmin (1934, p. 366) stated:

"Alternate methods of injection were rejected, because
the closely folded shales and compressional fault zones didn't contain open fissures, chemical replacement of invaded rocks by solid pebbles is not feasible, and a fluid medium cannot dissolve and remove with equal efficiency rocks of quartzite, shale, limestone, dolomite, and lava, in order to make room for deposition of "pebbles."

Many of these dikes are not closely associated with igneous dikes, and they are composed of broken limestone fragments. The dikes are mostly lenticular in shape with limited vertical and horizontal range.

Newsom (1903, p. 235) observed dipping bedding adjacent to the clastic dike. He reported that when the sand intruded a shale bed, its drag turned upward the bedding on both sides of the dike. The sandstone dike is overlain by broken shale as though the sand had not been forced completely through the shale.

Russell (1927, p. 407) pointed out that when the Black Hills region was deformed by uplift, the stresses produced by the tension or the slipping of one bed over another, forced the plastic sand into the fractures of the shale. He proved that the sand was injected from below by the use of fish scale fossils which were correlated with the under-lying marine sandstone of the Mowry formation.

Fuller (1912, p. 51) reports that in the New Madrid Earthquake area, many of the fissures pinch out before they reach the surface of the ground, and they were filled with intruding sand and water. Mc Millan (1931, p. 842) reports
that a fissure produced in a chalk bed either by settling or other forces, was filled from below with sand by ground water.

Submarine slumping, according to Fairbridge (1946, p. 87), is associated with clastic dikes. The movements seem to be contemporaneous with the emplacement of the clastic dike material, so the pressure of injection into the fissure must have been caused by the submarine slump. Monroe (1932, in Vitanage, 1954, p. 497) reported structures such as "crumplings, slip plane spiral rolls" and sandstone dikes, as being caused by submarine slumping and deposition of the sediments in tension cracks on the sea floor.

McCullie (1903, p. 201) noticed clastic dikes which were so irregular both in direction and size, and confined to a small area, that he believed them to be fissure fillings produced by a landslide.

**Leaching and removal**

Lahee (1952, p. 83) proposes a leaching and removal method of clastic dike formation. He reports that the detritus has been let down *pari passu* with the openings of spaces by gradual leaching and removal of the original materials in solution.

**CLASSIFICATION OF CLASTIC DIKES**

Shrock (1948, p. 212, *et. seq.* ) proposed a classification of clastic dikes based on genesis.

(1) "Those formed by intrusion of clastic or fluid material derived from some underlying source layer and emplaced under abnormal pressure."
(2) "Those formed by introduction of material from above, either under some pressure or by simple filling of a preexisting crack or crevice."

Lupher (1944, p. 1443) points out that clastic dikes "cannot be classified on the basis of physical characteristics, because the materials and structure are both complex and extremely variable within an individual dike."

The physical characters range from clay to gravel material, sorted to unsorted, stratified to unstratified, and if stratified, the stratification may be horizontal, inclined, or vertical in the same dike.

Lupher mentions that the character of the enclosing rock cannot be used as a basis for classification as it bears no relationship to the character of the dikes. Age as a basis for classification is poor as it tells very little. The two possibilities for clastic dike classification is the mode of fissure filling or origin of the fissures.

A classification based upon the mode of fissure filling may provide a workable basis for the analysis and interpretation of clastic dikes. It has been noted that in different areas the mode of filling may be quite complex, but generally, the dikes are related somewhat in different areas by their mode of fissure filling. It seems that clastic are formed by the filling of fissure through a surface opening or through a subsurface opening. It is upon this basis that the following classification is proposed:
Classification of Clastic Dikes

Dikes formed by the filling of an open surface fissure.

Sedimentation into an open surface fissure.

Type of clastic dike sediments
- Marine
- Luscustrine
- Fluvial
- Eluvial
- Eolian
- Collapse

Injection into an open surface fissure.

Type of clastic dike sediments
- Glacial
- Marine slump

Replacement and weathering

Type of clastic dike material
- Residual

Dikes formed by the filling of a subsurface fissure.

Injection from above the containing rocks into a subsurface fissure.

Injection from below the containing rocks into subsurface fissure.

SIGNIFICANCE OF CLASTIC DIKES

Economic value

According to Farmin (1934, p. 368) clastic dikes are closely associated with a few ore bodies in the Tintic, Utah, area. This leads to the conclusion that some of the clastic material entered the country rock through the same channel used by the mineralizing solutions, and that both entered at nearly, if not the same time. However, this
does not mean that all of the mineralizing solutions entered at this time.

Farmin (1934; p. 368) points out that many of the clastic dikes in the Tintic area do not contain any ore, but the presence of the clastic dikes indicate that the underlying ground has been subjected to intrusion and possibly to mineralization.

**Top and bottom criteria**

According to Shrock (1948, p. 220) if the strata transsected by clastic dikes should later be folded or faulted into steeply inclined attitudes, the top of the bed may be determined if the source of the dike material is known.

Shrock states:

"If the dike material was introduced from a buried source, the direction of the movement within the dike points toward the surface; and downward the material connects with the source bed. If, on the other hand, the material came from the surface and filled crevices and fissures open to the surface, its composition and relations to the unconformity between the intruded rock and overlying beds should indicate the direction toward the surface whence the original dike material came."

**Record of seismic activity**

The geologic structure of California is such that it was especially favorable for the formation of clastic dikes by earthquakes. The clastic dikes have furnished evidence that there was seismic movement in the area during the Tertiary (Diller, 1890, p. 442). Jenkins (1925b, p. 244) agrees that clastic dikes record former seismic disturbances.
In the Touchet area of Washington, clastic dikes are records of seismic disturbances of great magnitude.

According to Harms (1958, , abs. p. 12) sandstone dikes may be "used to locate hitherto, unrecognized thrust faults and give information regarding the direction and distribution of thrusting."

**Geomorphic feature**

Clastic dikes may persist as topographic features long after seismic activity has ceased. Near Santa Cruz, California clastic dikes stand out above the diatomaceous shale, because the dikes are harder and more resistant. These ridges are dark in color due to the presence of bitumin, and they are locally traceable. Their presence helps one to locate fracture systems that were produced by seismic activity. Usually the ridges are very low, ranging from a foot to several feet in height.

**SUMMARY AND CONCLUSIONS**

Clastic dikes are tabular bodies of clastic material transecting the structure and bedding of the enclosing rocks. The dikes may be either straight and parallel, or irregular, sinuous, or zigzag, and they may be either closely spaced or distantly spaced. The thickness of the dikes ranges from a mere film to 18 feet, but commonly, they are two to three feet thick. The dikes extend several yards or several miles in length. Sandstone sills, "sand sloughs;"
"sand blows" and clastic plugs are associated with clastic dikes. A preferred orientation of the elongated or flat grains may indicate the mode of fissure filling. Fissures are caused by earthquakes, faulting and folding, submarine slumping, and shrinkage. The dike material must have come from above or below the containing rocks. The dikes may be formed by the filling of a fissure exposed to the surface or by the filling of a subsurface fissure by injection. Clastic dikes may be classified by their mode of fissure filling. The dikes would then be separated into two groups:

1. Dikes formed by the filling of an open surface fissure by sedimentation, injection, or weathering and replacement.
2. Dikes formed by the filling of a subsurface fissure by injection from above or below the containing rocks. Injection is usually indicated by scales of mica, bedding, and flat, elongated grains standing on edge or parallel to the fissure walls. Deposition in an open fissure or an open surface crevice is usually indicated by stratification. The significance of clastic dikes is their economic value when associated with ore deposits, use as top and bottom criteria, use as a record of seismic activity, and as geomorphic features.
<table>
<thead>
<tr>
<th>Previous Workers</th>
<th>Date</th>
<th>Location</th>
<th>Containing Rocks</th>
<th>Age</th>
<th>Classification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diller</td>
<td>1890</td>
<td>NW Sacramento Valley</td>
<td>Horsetown sh. K Chico sh.</td>
<td>Sb I</td>
<td></td>
</tr>
<tr>
<td>Cross</td>
<td>1894</td>
<td>Colorado</td>
<td>Pikes Peak granite</td>
<td>PC</td>
<td>Sb I</td>
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<tr>
<td>Newsom</td>
<td>1903</td>
<td>Santa Cruz, California</td>
<td>Diatomaceous sh.</td>
<td>Tm</td>
<td>Sb I</td>
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<tr>
<td>Fuller</td>
<td>1912</td>
<td>Tennessee Missouri</td>
<td></td>
<td></td>
<td>Sb I</td>
</tr>
<tr>
<td>Parker</td>
<td>1933</td>
<td>Union County, New Mexico</td>
<td>Dockum grp. Tr</td>
<td></td>
<td>Sb I</td>
</tr>
<tr>
<td>Price</td>
<td>1933</td>
<td>Pennsylvania Virginia</td>
<td>Redstone coal Cp</td>
<td></td>
<td>Sb I</td>
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<tr>
<td>Kruger</td>
<td>1938</td>
<td>New Hampshire</td>
<td>granite</td>
<td>PC</td>
<td>S I</td>
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<tr>
<td>Fackler</td>
<td>1941</td>
<td>North shore of Lake Superior</td>
<td>lava</td>
<td>PC</td>
<td>S S</td>
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<tr>
<td>Vitanage</td>
<td>1954</td>
<td>South Platte, Colorado</td>
<td>granite</td>
<td>PC</td>
<td>Sb I</td>
</tr>
</tbody>
</table>

- T: Tertiary
- Tm: Miocene
- Tr: Triassic
- K: Cretaceous
- Cp: Pennsylvanian
- PC: Precambrian
- Sb Subsurface
- S: Surface
- I: Injection
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