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Classification of Clays

Primary and Secondary Clays

Once feldspar has decomposed over geologic time to form clay, the major factor determining quality and performance is whether and how far the clay has been moved by natural forces from the site of origin. *Primary* or *residual* clays are those remaining at the site of the parent rock. They are the purest clays, but also the least plastic because of large average particle size. *Secondary* or *deposited* clays include all the rest of the naturally occurring clays. Secondary clays have been transported by wind or water and subjected to natural grading and refining, leaving coarser particles behind but also introducing contaminants.

Types of Naturally-Occurring Clays

Kaolin or *china clay* is the essential primary clay, the source of most other clays. To be classified as a kaolin, a clay must have a certain level of purity, but that does not necessarily mean that it is a primary clay. True primary kaolins are the purest – the ones that remain right at their point of origin, breaking down underground over geological time. They fire pure white in color but are coarse in particle size.

The so-called *secondary* or *deposited kaolins* have been transported a short distance from the point of origin by natural forces but remain very pure. Transporting settles out the coarsest particles, so secondary kaolins tend to be far more plastic than true primary kaolins. Fine deposits of secondary kaolins are found in South Carolina, Georgia, and Florida, and include Tile-6 kaolin and EPK (Edgar Plastic Kaolin). Tile-6 and EPK are the most popular American kaolins for plastic porcelain bodies, but do produce a very slight off-white color due to slight iron and titanium contamination.

Ball Clays are chemically very similar to kaolins after firing, but are secondary clays transported a long distance by water and deposited in swampy areas like marshes and river deltas. All coarser particles settle out along the way and organic acids break down the particles farther to ultra-fine size, but organic contaminants are also introduced, primarily lignite coal. Ball clays feature ultra-fine particle size and high plasticity but also extremely high drying shrinkage, and thus are almost always used in combination with other clays. The most popular North American ball clay is OM-4 (Old Mine #4). OM-4 contains significant trace iron, and if whiteness is an issue for a porcelain body, Tennessee #10 ball clay has considerably less iron content.

Earthenware Clays, also known as *common clays*, *red clays*, or *surface clays*, are the most common secondary clays throughout world. Earthenware clays are transported far from the parent rock and deposited along river courses and contain considerable contaminants, including high concentrations of iron that give the raw clay its gray-blue color and the fired ware its red color. Iron in contact with silica can begin forming a glassy phase well below 2000 degrees F., giving classic *terracotta* bodies considerable fired strength at lowfire temperatures. True earthenware clay can never fully vitrify

because the higher content of strong flux that make it such a good lowfire claybody would begin dissolving the sintered structure, causing severe warping. By far the most popular raw earthenware clay processed and sold in the US today is *Cedar Heights Redart* clay.

Stoneware Clays are secondary clays transported far from the parent rock, giving more impurities, finer particle size, and a higher flux content, primarily calcium, feldspar, and iron. Most earthenware and stoneware deposits start out the same, but earthenware clays are recently formed in geologic time, while stoneware deposits are much older and generally bedded in the earth along with shale, slate, and coal. Over geologic time, ground water leaches away most iron and other fluxes. The variety and proportion of fluxes remaining are such that naturally-occurring stoneware clays like *Cedar Heights Goldart* will vitrify at highfire temperatures. These clays generally contain a wide range of particle sizes, and thus are not as plastic as ball clays but have much better working structure and lower drying and firing shrinkage. The iron content is far less than earthenware clays but still varies considerably, giving a range of fired colors from light buff to orange, red brown, medium brown, and dark brown.

Fireclays are secondary clays similar to stoneware clays but contain larger average particle size, and even more of the iron and other fluxes have been leached away so that even at highfire temps they are not fully vitrified. Occasionally fireclays contain a significant fraction of very fine particles giving good plasticity, and these are the so called *plastic fireclays* sought-after in studio ceramics. Many naturally-occurring fireclays are too coarse for studio use but ideal for manufacturing brick and kiln furniture.

Bentonite Clays can be primary or secondary, and have the finest particle size of all natural clays. Bentonites form when fine particulate airborne volcanic ash deposits in thick beds and decomposes over geologic time as groundwater leaches away most of the fluxes. Travel anywhere up and down the Great Plains and you will find vast deposits of bentonite clays. 70 million years ago the Rocky Mountains were born in the geological event known as the Laramide Orogeny, accompanied by explosive volcanic eruptions. Clouds of volcanic ash traveled east on the prevailing winds, and coarse particles dropped quickly while the finest were carried hundreds of miles and settled in beds from West Texas to Alberta, Canada. Exposed by erosion, alternating beds of bentonite, coarser clays, and shale erode to form the classic badlands topography found in many locations up and down the Great Plains.

Bentonites are higher in silica and lower in alumina than kaolin-based clays and usually contain significant traces of iron. They are especially useful as plasticizers or suspension agents, but the ultra-fine particle size may cause excessive drying shrinkage and associated problems if used in excessive amounts. Up to 3% of the dry materials weight will help plasticize a claybody or improve glaze suspension and adhesion to the wares. If whiteness is an issue, use enhanced bentonites like Macaloid or Veegum-T.

Slip clays such as Albany slip, Alberta slip, and Barnard or Blackbird slip are secondary clays containing such high percentages of iron and other fluxes that they melt to form a shiny glaze at highfire temperatures, generally ranging in color from medium to dark brown or gray\brown. Pure Albany slip is the famous dark brown liner glaze found on so much 19th-century utilitarian stoneware, but is no longer being mined. Alberta slip is the popular substitute, blended from a number of different slip clays by the Archie Bray Foundation.