Steve Speller

Crystal glaze

When pottery is glazed for a sparkling crystalline surface, it's difficult to predict the exact outcome. *Alison Goddard* meets a potter who wants to change this

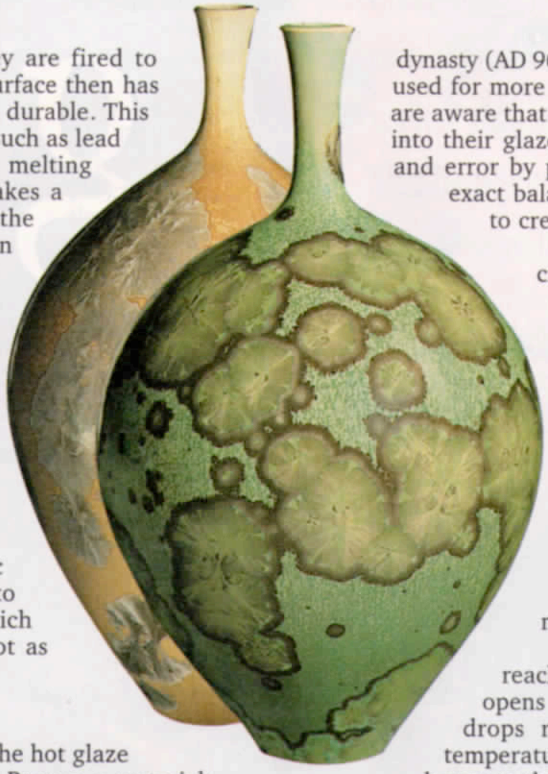
KATE MALONE sits among a clutter of bold and bright pottery in her north London studio. Her pottery sculptures—lobsters and fish, pineapples and pumpkins—are chunky, colourful and larger than life. Inspired by their shiny, watery qualities, Malone uses crystal glazes to coat her designs. These glazes are smooth to the touch, but sparkle with intricate patterns of flat crystals which spread across the surface.

But despite the stunning effects these glazes can create, Malone is one of only a handful of potters round the world who work with crystal glazes—few are willing to persevere with a technique which is renowned for being frustratingly unpredictable.

This is something Malone is hoping to change by developing her own range of new crystalline glazes. In 1994, the London Arts Board, which funds art exhibitions and training in Greater London, awarded her a modest grant of around £1000 to research the conditions under which crystals form. At the moment, she is concentrating on the chemical composition by varying the colour pigments added to two or three of her eight crystalline base glazes. "It's fascinating—it's alchemy," she says.

The technique for making standard, noncrystalline glazed pots is fairly

'There are few hard and fast rules to guide the potter. Crystal glazing dates back as far as the Sung dynasty, but it's still impossible to predict where the crystals will form'



David Seed

simple. After pots are shaped, they are fired to harden the clay. The dull, porous surface then has to be glazed to make it colourful and durable. This glaze is a silica powder with a flux, such as lead oxide, to give the mixture a lower melting point. Combining it with water makes a gooey mixture which is applied to the surface of the pot. The pots are then fired again, causing the glaze to melt and fuse, usually at temperatures of over 1000 °C. When the kiln temperature is then lowered, the glaze solidifies to become a glass—a hard, smooth surface without any kind of order in the arrangement of the molecules.

To obtain crystal glazes, on the other hand, high levels of zinc oxide have to be added to the glaze. As the glaze melts in the kiln, the zinc oxide combines with the silica to form willemite—zinc silicate—which crystallises on the surface of the pot as the temperature in the kiln falls.

Diverse liaisons

The first stages of crystal growth in the hot glaze are fairly unstable, according to Phil Rogers, a materials scientist at Imperial College, London. In a very tiny crystal, the number of atoms holding it together is small compared with the number of free bonds on its surface which are all too eager to form other liaisons. As the glaze cools and becomes more viscous, a crystal can eventually reach a stable size at which its inner, fully bound structure can remain in place indefinitely, grasping onto extra atoms as they pass the surface. Having established this critical nucleus, the stable crystal will continue to grow until the glaze solidifies.

Another way to grow crystals is to use a different material as a nucleus—any small lump that is already solid, such as a speck of dust or sand, or a lump of clay sticking out from the surface of the pot. Crystals form easily round these surrogate nuclei, according to Rogers. "You don't have to form a growth centre as it is already there," he says.

The size of the final crystals is governed mainly by the rate at which the glaze cools. Where it cools quickly, crystals do not have time to form, but where it cools slowly, large crystals can grow.

While modern chemistry can reveal the underlying processes at work, there are few hard and fast rules to guide the potter. Crystal glazes are an age-old craft, with oriental examples dating back to the Sung dynasty (AD 960 to 1279). In the West, they have been used for more than a hundred years. Modern potters are aware that they must mix high levels of zinc oxide into their glazes. The rest, however, is down to trial and error by potters who must struggle to find the exact balance of ingredients and kiln conditions to create their desired effect.

Potters have found, for instance, that crystal formation also requires strict control of the kiln temperature. Malone's kiln is initially brought up to a temperature at which the glaze melts, and runs down the sides of the pots. To compensate for this effect, she makes sure that the glaze is about three times as thick at the top (around 4 millimetres) than it is at the bottom of a pot. The peak temperature in her kiln is 1280 °C—hot enough for the glaze to melt and fuse, but not so hot that all the crystal nuclei flow off the surface.

When the maximum temperature is reached and the glaze has melted, Malone opens the kiln door so that the temperature drops rapidly to around 1090 °C; at this temperature the glaze is more viscous and clings better to the clay. The glaze then starts to solidify, and crystals begin to appear. Next, the temperature is very slowly lowered over several hours to give the zinc silicate crystals time to grow to a diameter of up to around two centimetres, before the glaze sets permanently in place. Malone can then open the kiln to see how the latest glazed pottery has turned out. "It feels like Christmas," she says.

Malone says that it's impossible to predict where the crystals will form because there are too many variables. The time

Kate Malone

Top: Big crystals characterise Clarkson's porcelain vases; adding manganese and cobalt gives a tan glaze with grey crystals, while copper produces shades of green. Bottom: the glaze containing cobalt on one of Malone's pots has run into folds and formed pools of crystals

Mimicking nature: Malone's pumpkin came out of the kiln with natural stripes

Peter Chatterton

taken for the temperature of the kiln to fall, combined with the shape of the pots, determines where the runny glaze accumulates in pools, and this in turn influences the cooling rate. Glaze which has run into thick pools cools more slowly, producing many large crystals if lots of nuclei have been swept into them. Other variables affect the cooling rate, including the thickness of the walls of the pots, their position in the kiln, and the density of the packing of other items.

"If you are lucky, you get crystals somewhere—you can't predict where," says Malone. When she created pumpkins for her *Fruits of the Earth* collection, she painted them all over with a honey-coloured glaze. When the pumpkins were fired, the glaze ran freely over the steeper surfaces into the folds, where it collected and cooled more slowly, forming crystals. "The crystals form stripes in the same way that nature forms stripes," says Malone, who had not planned the effect but was delighted with the result.

Magic effect

Since he officially retired from pottery five years ago, Derek Clarkson, a studio potter from Bacup in Lancashire, has also been working with crystalline glazes. As a student, he says, he saw an example at the Victoria & Albert Museum in London, "and the effect was magic". He says "The crystals looked like holograms—this was so different." Clarkson now creates enormous crystals up to 5 centimetres across as decorative motifs on elegant bottles made from smooth porcelain. This fine white clay does not contain the impurities which gives terracotta clay, for instance, its colour.

Clarkson experiments with his kiln firing schedules as well as the chemical composition of his glazes to produce crystals shaped like radiant rays and fans, battle axes and wheat sheaves. One technique he uses involves lowering the kiln temperature from 1082 °C to 1032 °C so that crystal growth is halted, and then quickly raising the temperature to 1093 °C before slowly cooling the kiln again. Crystal growth stops and then starts again, with the edge of the first crystal acting as a series of nuclei. The result is a large crystal with a smaller halo around it.

On the smooth porcelain clay, relatively few crystals form because there are fewer "lumps" for crystals to grow on. At a peak kiln temperature of 1280 °C, much of the glaze runs off the pots, washing away any specks of dust or sand from the surface. Only a few crystals can grow, an effect that Clarkson uses to characterise his work.

Using a white porcelain base also gives brighter colours with crystalline glazes—just as painted colours appear brighter when they are applied to a piece of white paper rather than a piece of brown paper. Clarkson adds small amounts of manganese and cobalt to his glazes with striking results. The manganese colours only the background to a pale tan, and the metallic grey of the cobalt shades only the crystals. Rogers explains that this is because cobalt has the right number of valence electrons to slot into the zinc silicate crystal lattice, whereas manganese does not.

Malone, meanwhile, has developed a repertoire of around a hundred colours. She uses nickel oxide to produce a honey-coloured glaze with turquoise crystals, for instance, and iron oxide to give honey crystals on a honey glaze. "Now that I have got a lot of colours, I'm thinking of concentrating more on experimenting with the shapes and the density of the crystals," she says. Among her pumpkins and giant fish, she has a long summer of potting ahead. □

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