

33. The price for multiwall carbon nanotubes has dropped from a few hundred U.S. dollars per gram in the 1990s to about 100 U.S. dollars per kilogram. See, for example, <http://www.azonano.com/details.asp?ArticleID=1108>.
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Materials and Methods

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Anomalous Metal-Rich Fluids Form Hydrothermal Ore Deposits

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Hydrothermal ore deposits form when metals, often as sulfides, precipitate in abundance from aqueous solutions in Earth's crust. Much of our knowledge of the fluids involved comes from studies of fluid inclusions trapped in silicates or carbonates that are believed to represent aliquots of the same solutions that precipitated the ores. We used laser ablation inductively coupled plasma mass spectrometry to test this paradigm by analysis of fluid inclusions in sphalerite from two contrasting zinc-lead ore systems. Metal contents in these inclusions are up to two orders of magnitude greater than those in quartz-hosted inclusions and are much higher than previously thought, suggesting that ore formation is linked to influx of anomalously metal-rich fluids into systems dominated by barren fluids for much of their life.

Hydrothermal ore deposits, formed from the flow of hot solutions through porous or fractured rocks, are the principal source of metals in Earth's crust (1). Such large accumulations of metal require concentration of elements hundreds or thousands of times above natural abundance, implying high-mass fluxes through small volumes of rock coupled with efficient precipitation. A fundamental control on the formation of hydrothermal deposits is the ability of the fluid to carry metals in solution (2). Yet, paradoxically, for most deposit types formed at low-to-intermediate temperatures, both direct analysis of fluid inclusions and theoretical calculation indicate that the concentrations of dissolved metals are likely to be low, on the order of tens of parts per million (3). Also, samples of modern crustal fluids, such as those from oil fields or mid-ocean ridges, typically contain only a few parts per million of Cu, Zn, and Pb (4, 5), although there are exceptions, such as the Salton Sea geothermal brines in California (6) and oil-field waters from central Mississippi (4). A consequence is that the other parameters that govern total metal flux in ore formation (average flow velocity and system lifetime) tend toward their

likely geological limits in both numerical simulations and empirical models based on geological and geochronological constraints (7, 8). As a result, it has been suggested that higher-than-normal concentrations of metal in fluids may be required to form large ore bodies (9).

For several decades, a key source of information on the physical and chemical conditions of hydrothermal ore formation has been fluid inclusions trapped during mineral growth (10). In most deposits, metalliferous ore minerals (commonly opaque sulfides) occur together with uneconomic transparent phases (gangue). Because fluid inclusions in the opaque phases are not easily studied by traditional transmitted light microscopy and microanalytical methods, the nature of ore-forming fluids and the conditions of ore-mineral precipitation have often been inferred from the properties of inclusions trapped in the associated gangue minerals. However, it is often difficult to provide unequivocal evidence for coprecipitation based on textural observations or isotopic measurements (11); consequently, uncertainty remains concerning the temporal and, therefore, genetic relationship between gangue-hosted inclusions and the ore-forming process. Several studies that used infrared light microscopy to observe inclusions in opaque minerals such as wolframite and cassiterite have shown that the properties of these fluid inclusions may, indeed, be different (12).

We analyzed fluid inclusions in sphalerite (ZnS) from two zinc-lead ore systems with the use of laser ablation inductively coupled plasma mass spectrometry (LA-ICPMS). Primary inclusions in sphalerite must represent the ore-forming fluid because they are trapped during growth of the ore mineral itself. Unlike bulk analytical studies that are limited to a few major elements

and that may sample multiple populations of inclusions (13), LA-ICPMS allows determination of trace elements (including ore metals) in single, texturally constrained inclusions.

We selected samples from two well-studied hydrothermal ore systems. The Northern Arkansas district of the Ozark Plateau, North America, is an example of low-temperature Mississippi Valley-Type (MVT) zinc-lead mineralization, thought to have formed by continent-scale basinal brine migration (14). The Midlands Basin orefield in Ireland contains several large zinc-lead(-barium) ore deposits formed from moderate temperature fluids generated by deep crustal circulation of seawater-derived brines during continental rifting (15, 16). Both systems are economically noteworthy but provide a contrast in terms of sources of metals, sulfur, and hydrological regime. Lead is of particular interest because it needs to be concentrated above average crustal abundance more than any other common ore-forming element (~4000 times) to form a potentially economic accumulation.

Samples from Northern Arkansas were collected from exposures in the Monte Cristo and Philadelphia Mines of the Rush subdistrict and from the Lucky Dog Mine of the Tomahawk Creek subdistrict. They comprise fine- to coarse-grained crystalline quartz and medium- to coarse-grained pale yellow-to-brown sphalerite. Regionally, precipitation of sphalerite typically overlapped with that of jasperoid and finely crystalline quartz, and more coarsely crystalline quartz formed later (17). Samples from Ireland were collected from historic mine exposures and drill core from the Silvermines deposit, as well as from quarry outcrop of quartz-sulfide veins nearby. The deposit samples are composed of massive sulfide dominated by coarse-grained brown sphalerite that replaces early disseminated granular and framboidal pyrite. The vein sample is composed of quartz and ankerite, as well as minor sphalerite and galena, and was selected as a representative example of a regionally developed set of feeder veins developed underneath the ore deposits (18, 19).

Salinity data derived from freezing experiments (20) show that the Northern Arkansas mineralization formed from brines, typical of MVT deposits (Fig. 1). Assuming fluids were trapped at hydrostatic pressure at depths of <2 km, the inferred depth of ore formation (14), we calculated an isochoric correction of <+10°C to recorded homogenization temperature (T_h) values to give true trapping temperatures. Thus, T_h can be regarded as a reasonable approximation of fluid temperature during mineral growth. Inclusions from the Irish samples display lower salin-

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ity and higher T_h values than the MVT fluids (Fig. 1), typical for the Irish orefield (11). For the Irish ores, which formed at shallow depth (16, 19), any correction to homogenization temperatures will again be small so that T_h values can be regarded as a good proxy for fluid trapping temperature.

Laser ablation analyses were carried out with the use of a New Wave UP213AI, 213-nm aperture-imaged laser ablation system (20–22) on primary fluid inclusions interpreted to have

formed during initial mineral growth based on conventional petrographic criteria (10). Some secondary inclusions, formed during later fracturing and annealing, were analyzed for comparison (Fig. 2). Lead and other elements of interest in hydrothermal systems such as Ba and Mn are clearly present in the fluid phase, as indicated by their good correlation with Cl in inclusion signals (Fig. 3). Full data are reported in tables S1 and S2 (20).

Zn concentrations in primary quartz-hosted inclusions from Northern Arkansas are low, rang-

ing from 0.12 to 12.3 parts per million (ppm). In Irish quartz, except for one primary inclusion (14 ppm), Zn was below the limit of detection (mean = 37.6 ppm) because of the small inclusion size. Such low Zn concentrations are consistent with previously reported bulk analyses of 3.4 to 6.0 ppm (16). Unfortunately, we were not able to measure the Zn concentration of inclusions trapped in sphalerite because of the overwhelming host mineral contribution to the laser ablation signal. A similar problem also occurred for Cu (Fig. 3). However, Pb can be used as an indicator of the ore metal content of these inclusions, as it does not substitute appreciably into sphalerite, and its presence there can be corrected for (20).

In Northern Arkansas, Pb concentrations display a marked bimodal distribution, ranging from 0.2 to 3.5 ppm in quartz and primarily from 10 to 400 ppm in sphalerite (Fig. 4). This excludes five sphalerite-hosted inclusions that fall in the lower population, interpreted to represent unrecognized secondary inclusions trapping fluid related to the later quartz. The quartz-hosted inclusion data are consistent with a 266-nm LA-ICPMS study that found that fluid inclusions in gangue minerals from the Southeast Missouri MVT district contained Pb, Zn, and Cu concentrations below instrumental detection limits of ~10 ppm (23). The Monte Cristo and Philadelphia sphalerites have similar mean Pb concentrations (80 ppm) that are lower than the Lucky Dog sphalerites (119 ppm).

In Ireland, we also observed a distinction between the Pb content of primary inclusions in quartz (3.6 to 26 ppm) and sphalerite (22 to 890 ppm) (Fig. 4). The quartz-hosted inclusion data are consistent with bulk fluid inclusion analyses for Irish feeder veins that gave Pb concentrations of 11.4 to 19.8 ppm (16). The more saline primary inclusions in sphalerite 75-85-104 have a higher mean Pb concentration (430 ppm) than the

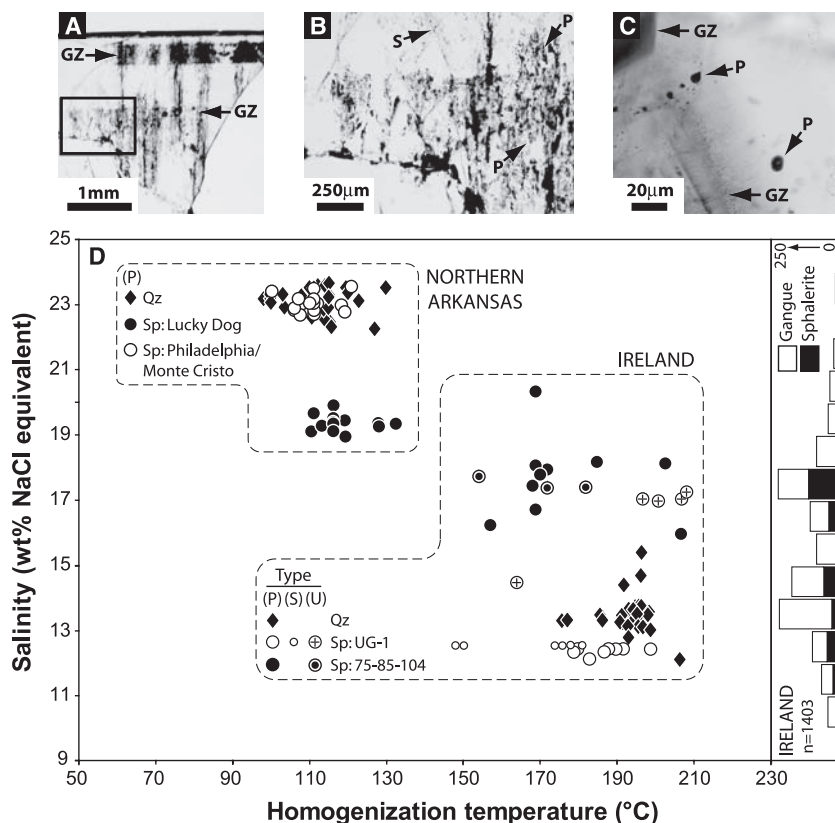


Fig. 1. (A) Quartz wafer from Northern Arkansas showing primary growth zones (GZ). (B) Magnification of inset shown in (A) illustrating complex distribution of fluid inclusions, together with some secondary trails (S) and selected primary inclusions (P) within growth clusters. (C) Sphalerite wafer from Ireland showing growth zones defined by fine fluid inclusions and color banding, together with euhedral primary inclusions. (D) Plot of fluid temperature and salinity data derived from microthermometry. Salinity was estimated from the freezing point depression of ice, modeled in the NaCl-H₂O system (20). For Northern Arkansas [data previously shown in (17)], quartz from Monte Cristo and sphalerite (Sp) from Monte Cristo and Philadelphia contain apparently identical primary inclusions. Slightly lower salinity primary inclusions are found in sphalerite from the Lucky Dog mine (20 km to the southwest), indicating geographic variability in brine composition. In the Irish Orefield, UG-1 sphalerite contains primary and secondary inclusions of a less saline brine [12 to 15 weight percent (wt %) NaCl equivalent] and a trail of inclusions of more saline fluids (16 to 18 wt % NaCl equivalent). This cuts a growth zone boundary (Fig. 2), indicating that these fluids are younger than this surface and its associated primary inclusions, but the exact timing with respect to other inclusions in the sample is uncertain (U). Fluids in the more saline population are trapped as primary inclusions in sphalerite 75-85-104. The data display a bimodal salinity distribution that mirrors the distribution observed in regional-scale fluid inclusion studies (see histogram at right), suggesting that these modes reflect multiple pulses of districtwide flow affecting a rock volume estimated at >130,000 km³. Analogous brine pulses have been inferred in the recent history of the Salton Trough geothermal field (6). The evidence noted above, together with crosscutting relations observed in other samples, suggests that the higher salinity fluid pulse is later and is associated with the majority of the sphalerite in the district. The inclusions analyzed by LA-ICPMS in sphalerite sample 75-85-104 are not plotted because homogenization experiments could not be carried out due to problems with leakage.

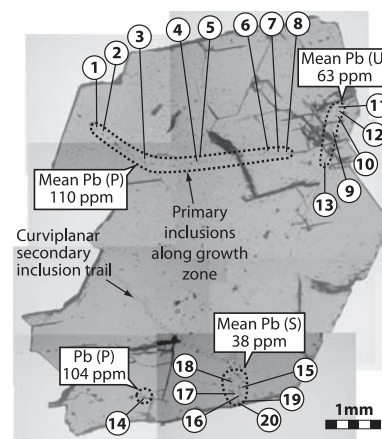


Fig. 2. Transmitted light digital photomontage of double-polished fluid inclusion wafer (~100 μm thick) of Irish sphalerite UG-1. Shown are individual fluid inclusions analyzed (numbered) and average determined Pb concentrations for each population of primary, secondary, or uncertain inclusions (same as those referred to in Fig. 1).

Fig. 3. (A). Example of a time-resolved laser ablation spectrum for a fluid inclusion in sphalerite (primary inclusion 9, Irish sphalerite 75-85-104). Initially, gas background was acquired and then the laser was turned on at 24 s. Signals for ^{66}Zn and ^{65}Cu increase as sphalerite begins to be ablated. The inclusion was breached at ~52 s. The signal was integrated offline over an ~16-s interval. The y axis is scaled from maximum to minimum recorded counts per second (cps) for each individual isotope. **(B)** The good correlations between the intensity for ^{35}Cl (only present in the fluid inclusion) and all isotopes measured (except ^{65}Cu) through the integration interval confirms their predominance in the fluid phase. This analysis returned 160 ppm Li, 530 ppm Mg, 7740 ppm K, 17500 ppm Ca, 530 ppm Mn, 2750 ppm Sr, 1770 ppm Ba, and 61 ppm Pb.

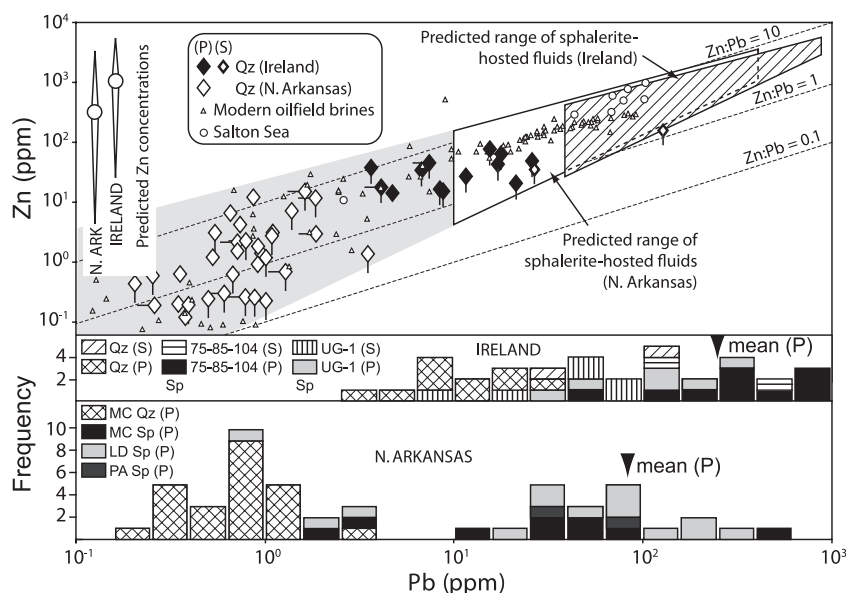
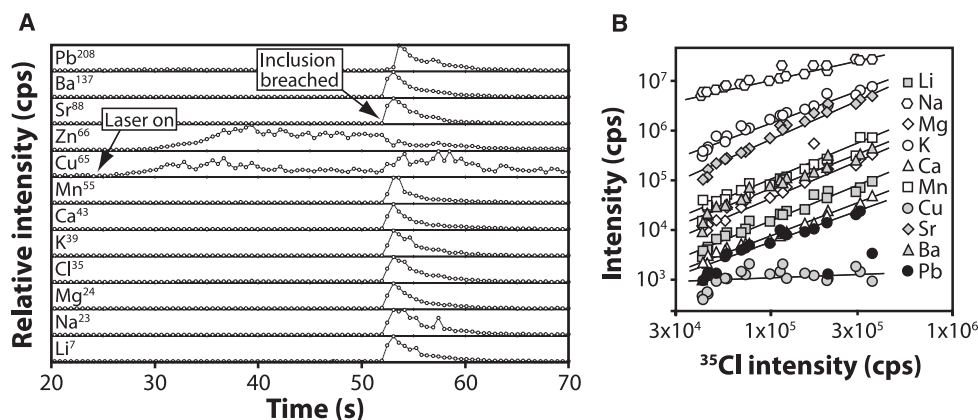


Fig. 4. Concentrations of Zn versus Pb in quartz-hosted fluid inclusions and histograms showing measured Pb concentrations in quartz- and sphalerite-hosted inclusions, compared with natural brine data from broadly analogous environments. Predicted Pb-Zn covariation for sphalerite-hosted inclusions indicated by fields, based on the extrapolation of empirical Pb-Zn concentrations, including data from modern oil-field waters (24, 25) adjusted to mass/mass units and from the Salton Sea geothermal field (6). Both of these data sets have values that fall in our “high-metal” fluid fields, suggesting that they are anomalously metalliferous and viable ore-forming fluids. Typical Zn:Pb ratios (by mass) for natural fluids are in the range of 1 to 10 (dashed lines) and tend toward higher values at elevated concentrations. Five data points from the Northern Arkansas data set with low detected Pb are inferred secondary inclusions. Short bars on symbols indicate that the plotted value is a maximum (limit of detection) value for that element. Qz, quartz; Sp, sphalerite; MC, Monte Cristo; PA, Philadelphia; LD, Lucky Dog. Some of the Northern Arkansas data shown are presented in (17), figures 6 and 7.

inclusions in sphalerite UG-1 (120 ppm); secondary inclusions in both samples display similar, lower concentrations. Two secondary inclusions in quartz contained higher metal concentrations (27 to 128 ppm) (Fig. 4) than the primary inclusions, indicating overprinting by later, more metalliferous fluids such as those trapped in sphalerite.

Pb and Zn concentrations are commonly correlated in hydrothermal solutions as a result of their similar geochemical behavior and

potential buffering by their respective sulfides (4, 24). This is illustrated by their empirical covariation in modern basin brines (4, 6, 24–26) and in the quartz-hosted inclusions in this study (above ~1 ppm) where both metals were determined (Fig. 4). This relation allows us to model the likely range of Zn concentrations to be expected in the sphalerite-hosted inclusions at the time of trapping: up to 5000 ppm in Irish sphalerite and 3000 ppm in Northern Arkansas. The latter estimate is ~60% of the value predicted

theoretically from thermodynamic data using measured Pb concentrations, assuming galena and sphalerite saturation and making reasonable assumptions about pH and oxygen fugacity (17). Although these are only order-of-magnitude estimates, it is clear that the fluids precipitating sphalerite were markedly enriched in Pb and Zn compared with those precipitating quartz in the two systems.

It could be argued that the fluid inclusions in quartz represent spent ore fluids, trapped after sulfide precipitation had already taken place. This is thought to be unlikely in the Irish deposits because the quartz was sampled from largely barren vein systems that formed beneath the ore deposits, in hydrothermal upflow zones (16), and the fluids show no signs of having substantially cooled or mixed (Fig. 1), as is known to occur during mineralization (16, 19). In the Tri-State MVT district, we found sphalerite- and quartz-hosted brine inclusions to have distinct halogen signatures, indicating that the fluids had separate origins (17). The fertile ore fluids appear to have originated during strong evaporation of seawater at Earth's surface, before later burial and expulsion. This observation contrasts with the barren fluids that evolved from less strongly evaporated seawater (17). The metalliferous fluids are therefore linked to the paleoclimate and the specific characteristics of the sedimentary aquifer within which they were trapped. The development of low-pH surface brines in the U.S. mid-continent in the Permian via sulfide oxidation (27) is an intriguing possible origin for such metal-prone fluids. Not only will unusually low pH enhance metal solubilization, but the reservoir rocks will be depleted in reduced sulfur that would otherwise limit metal take-up. The nonideal behavior of Cl at high ionic strengths, coupled with low pH and chloride complexing, has been cited as a control of high Zn and Pb concentrations in the most saline modern oil-field waters (6), but this does not account for the low metal concentrations observed in similar salinity brines in some oil fields or those trapped in gangue minerals in this study (Fig. 4). Irrespective of the origin, both numerical models (8) and empirical observation

of brine heterogeneity in modern sedimentary basins (6) imply inefficiency of mixing and the potential for preservation of individual, metal-charged brine reservoirs that could be tapped at some later time.

In the case of Ireland, the origin of metal-enriched fluids is uncertain, although a deepening convective flow system (15) has the capability to extract higher concentrations of metal later in the life of the system due to increasing temperature and possibly also progressive exhaustion of the buffer capacity for pH (by feldspar-mica) or the activity of H_2S (by pyrite-Fe silicate) on the convective flow path. The observation that the texturally later brines have higher metal contents is consistent with this model, although their higher salinity is also likely to have contributed to enhanced metal transport. The high Ba content of the metalliferous fluids (up to 6000 ppm) indicates that the oxidized sulfur content must have been low, limited by barite saturation. Combined with high base metal concentrations that imply low reduced sulfur concentrations, we conclude that a key property of these fluids was low ΣS (total sulfur concentration).

High metal concentrations may pertain in other types of hydrothermal ore systems, such as epithermal or volcanic-hosted massive sulfide deposits. In these environments, periodic injection of metalliferous magmatic fluids may be responsible for the bulk of metal introduction (28–30) into systems otherwise dominated by barren geothermal waters. A number of large, high-temperature, magmatic-hydrothermal deposits are also known to have formed from magmatic fluids that contained very high concentrations of ore metals (31–33). Accepting that hydrothermal ores may form specifically from anomalously metal-rich batches of fluid implies

geochemically specialized source regions and an episodicity and potentially short duration of ore-forming events that may be controlled by changes in hydrology. Although the existence of an efficient trap for these metals remains a fundamental prerequisite for hydrothermal ore formation, our interpretation contrasts with the view that many crustal fluids are viable ore fluids subject to the right perturbations in physicochemical conditions to cause efficient deposition (24).

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Tables S1 and S2

References

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Signature of the End-Cretaceous Mass Extinction in the Modern Biota

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The long-term effects of mass extinctions on spatial and evolutionary dynamics have been poorly studied. Here we show that the evolutionary consequences of the end-Cretaceous [Cretaceous/Paleogene (K/Pg)] mass extinction persist in present-day biogeography. The geologic ages of genera of living marine bivalves show a significant break from a smooth exponential distribution, corresponding to the K/Pg boundary. The break reflects a permanent increase in origination rates, intermediate between the Mesozoic rate and the post-extinction recovery pulse. This global rate shift is most clearly seen today in tropical bioprovinces and weakens toward the poles. Coupled with the modern geographic distributions of taxa originating before and after the K/Pg boundary, this spatial pattern indicates that tropical origination rates after the K/Pg event have left a permanent mark on the taxonomic and biogeographic structure of the modern biota, despite the complex Cenozoic history of marine environments.

The major extinctions of the geologic past, each of which removed >50% of well-preserved genera and perhaps >70% of their species (1, 2), irreversibly restructured the taxonomic composition of the global biota.

Although the broad macroevolutionary consequences of mass extinctions are well known (as in the dinosaurs-mammals changeover), their long-term effects on the temporal and spatial dynamics of clades and biotas are rarely inves-

tigated. For example, the good fit of modern biodiversity to local temperatures and to refugia from recent glaciations (3, 4) might imply that the recovery from the most recent major extinction, at the end of the Cretaceous Period 65 million years ago (Ma) [the Cretaceous/Paleogene (K/Pg) extinction], is largely obscured by subsequent events.

Here, we show the lasting influence of the K/Pg mass extinction on the evolutionary and biogeographic structure of modern biotas, using backward survivorship curves (BSCs, also called pre-nascence curves), which plot the proportion of taxa within a cohort that originated before some reference time (5, 6). Assuming that rates are time-specific and taxonomically homogeneous (5), a BSC defines an exponential probability function governed only by the origination rate (λ) of the cohort (7). The slope of a BSC is insen-

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Anomalously Metal-Rich Fluids form Hydrothermal Ore Deposits

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MATERIALS AND METHODS

Microthermometric Analysis

Fluid inclusions were analyzed using a Linkam™ MDS600 heating-freezing stage, employing standard laboratory procedures (S1). Stage calibration was carried out at -56.6, 0.0, +10.0, +30.4 and 294°C using in-house synthetic H₂O-CO₂ fluid inclusion standards. Measurement precision was generally $\pm 0.1^\circ\text{C}$ and estimated accuracy was $\pm 0.2^\circ\text{C}$ in the range -60 to +200°C. The temperatures of ice melting and liquid-vapor homogenization were measured in all inclusions. First (eutectic) melting and hydrate melting were recorded in the larger inclusions in which it could be observed more easily. Measurements of phase transitions were normally duplicated to ensure reliable data were obtained. In the absence of a complete hydrate melting dataset, estimates of the Cl content of the fluid inclusions were derived from final ice melting temperatures based on the NaCl-H₂O system (S2). Our modeling of compositions in the NaCl-CaCl₂-H₂O system (that is most appropriate for the fluids examined in this study) shows that for inclusions in which ice is the final phase to melt, and that fall in the typical natural range of NaCl/(NaCl+CaCl₂) ratios of 1.0-0.5, the error in our Cl values using this approach will be between +0.4% and -1.6%.

Laser Ablation ICP-MS Analysis

Laser ablation analyses were mainly carried out on primary fluid inclusions interpreted to have formed during initial mineral growth based on conventional petrographic criteria (S3). Some secondary inclusions, formed during later fracturing and annealing, were analyzed for comparison.

Inclusions were ablated using a New-Wave UP213AI, 213 nm aperture-imaged laser ablation system equipped with beam homogenization optics (S4). Ablated particulate material was analyzed by a Thermo Element PlasmaQuad 3 ICP-MS with enhanced sensitivity S-option interface, housed in the Natural History Museum, London. The transport gas was a mixture of He and Ar, at typical flow rates of ~ 1.1 and ~ 0.7 l min⁻¹ respectively. Stable ablation, critical for reproducible analyses, is best achieved by focusing the beam at the sample surface and gradually increasing laser output energy with a constant repetition rate of 20 Hz. Output energy is then held constant until fluid release is achieved. This technique enables a cylindrical hole to be drilled down to the inclusion of interest, normally up to 100 μm below the sample surface (S5). Beam diameter can be adjusted, according to inclusion size, prior to analysis and was normally in the range ~ 15 -25 μm .

Calibration (external standardization) was carried out at the beginning and end of each experiment by ablating two wax-tipped, pure quartz glass capillaries (typical external diameter 350 μm , internal diameter 250 μm , 10 mm in length) completely filled with a standard multielement solution (S5). NIST612 glass standards were also analyzed routinely as

an additional control. Calibration using solution standards was preferred to NIST glass due to a better matrix match with natural inclusions. The total salinity and concentration of minor elements in the multielement solution can be broadly matched to the natural inclusion fluid, based on microthermometric results and previous bulk fluid inclusion analyses. This approach results in generally improved (but markedly element-specific) accuracy and slightly degraded reproducibility relative to glass calibrations (S6).

Element ratios to an internal standard element (CI) were determined by referencing background-corrected integrated intensities from transient inclusion signals to the external standard. Absolute element concentrations were obtained from estimates of the CI content of the fluid inclusions derived from microthermometry. Up to 40 major and trace elements can be determined, although here we analyzed a reduced suite of 12 elements to improve quantification. This system has broadly similar capabilities to that applied in a number of hydrothermal ore studies [e.g., (S7)].

Inclusion signal intensities in sphalerite were corrected for minor contributions from the host mineral using the expression $I_{an}^{INC} = I_{an}^{MIX} - I_{he}^{MIX} \cdot \frac{I_{an}^{MIN}}{I_{he}^{MIN}}$ where I is the gas background corrected mean intensity (in counts per second), the subscript an refers to the analyte element, he an element dominantly present in the host mineral (in this case Zn), and the superscripts INC , MIX and MIN refer to the pure inclusion signal, the mixed inclusion+host signal and the mineral only signal. This processing was done using the bespoke software program Exlam2000 (S8). Precision (relative standard deviation) for this method is typically better than 25% for K, Ca and Sr and 20-50% for Mg, Pb and Zn (S5), broadly comparable with previous studies (S7). Limits of detection were normally set at a conservative 3σ of the background signal variation providing a robust filter of ablation signals. However, this was relaxed to 2σ for Pb and Zn in Irish quartz-hosted inclusions due to their small size.

Full data are reported in Tables S1 and S2. Table S2 was previously presented in (S9).

Table S1. LA-ICP-MS results for fluid inclusions from Ireland.

LA-ICP-MS Results (ppm)

IRISH SPHALERITE: UG-1				581830, 671030 Irish Transverse Mercator (ITM)											
Mode	FIA	Inc#	Note	Run No.	7Li	24Mg	35Cl	39K	43Ca	55Mn	65Cu	66Zn	88Sr	137Ba	208Pb
P	1	2		ap21f05	4.0E+02	5.6E+02	7.48E+04	< 651.3	2.0E+04	5.7E+02	ND	ND	4.0E+02	1.4E+03	3.9E+01
P	1	1		ap21f06	< 293.6	5.7E+02	7.55E+04	< 2500.8	< 53868.1	< 651.6	ND	ND	3.6E+02	1.3E+03	1.4E+02
P	1	3		ap21f07	8.6E+02	8.3E+02	7.34E+04	1.7E+03	1.8E+04	2.9E+02	ND	ND	5.5E+02	2.8E+03	5.8E+01
P	1	4		ap21f08	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
P	1	5		ap21f09	1.0E+03	6.7E+02	7.55E+04	< 6774.0	< 146722.2	< 1058.2	ND	ND	6.4E+02	1.7E+03	< 82.3
P	1	6		ap21f10	7.0E+02	8.5E+02	7.55E+04	< 1892.2	< 46052.4	< 513.9	ND	ND	6.4E+02	3.5E+03	< 21.7
P	1	7		ap21f11	< 450.3	4.4E+02	7.55E+04	< 3893.7	< 65503.3	7.4E+02	ND	ND	3.3E+02	2.2E+03	2.0E+02
P	1	8		ap21f12	< 559.3	5.9E+02	7.55E+04	< 2488.6	< 58666.0	< 617.3	ND	ND	4.6E+02	2.0E+03	3.1E+02
P?	2	14		ap21e13	< 482.4	3.4E+02	8.79E+04	< 4286.2	< 88772.8	< 449.0	ND	ND	3.0E+02	8.6E+02	1.1E+02
PS/S	4	13		ap21e14	5.8E+02	6.6E+02	1.05E+05	1.6E+03	3.8E+04	6.4E+02	ND	ND	2.1E+03	2.4E+04	2.2E+01
PS/S	4	10		ap21f13	1.0E+03	1.5E+03	1.03E+05	2.5E+03	6.0E+04	1.5E+03	ND	ND	5.3E+03	2.8E+04	9.6E+01
PS/S	4	9		ap21f14	7.2E+02	1.2E+03	1.03E+05	1.8E+03	4.4E+04	1.2E+03	ND	ND	6.8E+03	5.6E+04	< 10.8
PS/S	4	11		ap21f15	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
PS/S	4	12		ap21f16	9.6E+02	4.7E+02	1.03E+05	< 1204.1	1.9E+05	7.3E+02	ND	ND	5.2E+03	1.1E+04	7.1E+01
S	3	15		ap21e07	1.4E+03	1.6E+03	7.62E+04	ND	4.6E+04	4.9E+02	ND	ND	1.4E+03	3.8E+03	9.6E+00
S	3	20		ap21e08	< 618.9	< 385.7	7.62E+04	< 6776.5	< 72871.3	< 703.8	ND	ND	1.0E+02	1.6E+03	< 46.1
S	3	19		ap21e09	8.0E+02	9.6E+02	7.62E+04	1.9E+03	< 41093.4	5.4E+02	ND	ND	8.0E+02	3.1E+03	4.5E+01
S	3	17		ap21e10	4.6E+02	9.5E+02	7.62E+04	2.7E+03	< 59642.1	< 553.0	ND	ND	9.6E+02	1.4E+03	< 19.6
S	3	16		ap21e11	3.1E+02	3.6E+02	7.62E+04	1.9E+03	2.4E+04	3.1E+02	ND	ND	4.1E+02	9.4E+02	5.9E+01
S	3	18		ap21e12	5.1E+02	9.3E+02	7.62E+04	2.7E+03	< 55714.1	< 348.3	ND	ND	5.9E+02	2.4E+03	< 28.8
IRISH SPHALERITE: 75-85-104				584020, 670880 Irish Transverse Mercator (ITM)											
Mode	FIA	Inc#	Note	Run No.	7Li	24Mg	35Cl	39K	43Ca	55Mn	65Cu	66Zn	88Sr	137Ba	208Pb
P	1	1		no07c05	2.2E+02	5.6E+02	9.68E+04	1.2E+04	2.4E+04	5.2E+02	ND	ND	3.8E+03	5.1E+03	3.1E+02
P	1	2		no07c06	1.3E+02	3.1E+02	9.33E+04	7.0E+03	1.2E+04	3.2E+02	ND	ND	2.1E+03	2.9E+03	4.0E+02
PS	2	3		no07c07	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
PS?	2	4		no07c08	1.2E+02	3.2E+02	1.00E+05	2.7E+03	1.1E+04	3.3E+02	ND	ND	1.6E+03	1.4E+03	ND
P	5	9		no07c14	1.6E+02	5.3E+02	1.01E+05	7.7E+03	1.7E+04	5.3E+02	ND	ND	2.6E+03	1.8E+03	6.1E+01
P	6	10		no07c15	1.5E+02	3.5E+02	1.04E+05	3.7E+03	1.3E+04	2.9E+02	ND	ND	1.7E+03	1.3E+03	5.5E+02
P	6	11		no07c16	2.1E+02	4.2E+02	9.91E+04	4.7E+03	1.8E+04	4.7E+02	ND	ND	1.6E+03	1.9E+03	6.8E+02
PS	7	12		no07d05	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
PS	7	13		no07d06	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
PS	8	14		no07d07	1.7E+02	3.9E+02	1.04E+05	3.6E+03	1.7E+04	2.4E+02	ND	ND	1.6E+03	1.6E+03	3.9E+02
P	9	15		no07d08	2.4E+02	6.4E+02	1.17E+05	6.8E+03	3.0E+04	4.0E+02	ND	ND	2.5E+03	3.3E+03	8.9E+02
P?	11	19		no07d12	1.8E+02	5.5E+02	1.04E+05	5.3E+03	2.2E+04	3.1E+02	ND	ND	2.1E+03	2.0E+03	1.2E+02
P	12	16		no07d09	2.8E+02	5.3E+02	1.12E+05	7.1E+03	3.0E+04	3.3E+02	ND	ND	4.3E+03	6.0E+03	7.1E+02
P?	12	18		no07d11	1.9E+02	5.2E+02	1.04E+05	5.3E+03	2.1E+04	3.0E+02	ND	ND	2.5E+03	3.0E+03	2.0E+02
S?	3	6		no07c11	< 159.0	2.4E+02	9.50E+04	5.3E+03	1.8E+04	< 168.9	ND	ND	1.2E+03	8.5E+02	< 9.7
S?	4	7		no07c12	1.6E+02	2.0E+02	9.91E+04	1.7E+03	1.4E+04	< 117.3	ND	ND	2.5E+03	1.9E+03	< 7.7
S?	10	17		no07d10	2.0E+02	5.9E+02	1.12E+05	4.2E+03	2.1E+04	3.5E+02	ND	ND	1.9E+03	2.3E+03	< 2.6
S	13	8		no07c13	8.6E+01	3.4E+02	9.27E+04	3.3E+03	1.4E+04	3.4E+02	ND	ND	1.3E+03	1.1E+03	< 4.4
S	14	20		no07d13	1.7E+02	4.3E+02	9.50E+04	3.5E+03	1.7E+04	2.5E+02	ND	ND	1.7E+03	1.7E+03	4.4E+02
S	14	21		no07d14	< 360.9	8.6E+02	9.50E+04	< 5883.5	3.3E+04	5.2E+02	ND	ND	3.3E+03	3.5E+03	1.1E+02
S	14	22		no07d15	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
S	14	23		no07d16	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
IRISH QUARTZ: KEL-16*				599280, 668590 Irish Transverse Mercator (ITM)											
Mode	FIA	Inc#	Note	Run No.	7Li	24Mg	35Cl	39K	43Ca	55Mn	65Cu	66Zn	88Sr	137Ba	208Pb
P	2			no07a06	< 603.4	< 1474.9	8.15E+04	< 4058.2	< 18659.7	< 87	Not in menu	1.40E+01	1.0E+03	7.9E+02	4.7E+00
P	3			no07a07	< 1692.3	< 3458.5	8.15E+04	< 104045	< 43047.2	< 197	Not in menu	< 78.2	6.9E+02	4.3E+02	1.6E+01
P	4			no07a08	< 502.2	< 806.8	9.33E+04	< 4871.7	< 14632.9	< 76.2	Not in menu	< 17.0	7.3E+02	5.5E+02	8.4E+00
P	8			no07a12	< 899.8	< 2066.3	8.28E+04	< 5104.1	< 25954	< 146.8	Not in menu	< 37.7	9.5E+02	7.8E+02	3.6E+00
P	9			no07a13	9.3E+02	< 2658.4	8.15E+04	< 6208.6	< 30318.2	< 94.6	Not in menu	< 42.9	8.0E+02	7.3E+02	1.7E+01
P	12		Claithrate	no07a16	< 618.3	< 1070.7	8.73E+04	< 2135.1	< 17058.1	< 57	Not in menu	< 14.7	8.9E+02	5.6E+02	8.7E+00
P	13			no07b05	< 1782.4	< 1485	9.15E+04	< 4411.9	< 17979.2	< 64.2	Not in menu	< 64.2	4.8E+02	3.0E+02	< 4.1
P	14			no07b06	< 4576.7	< 4803.2	8.53E+04	< 11492.2	< 45954.9	< 351	Not in menu	< 17.8	2.7E+02	1.7E+02	< 1.9
P	15			no07b07	< 3873.4	< 2991	8.34E+04	< 12293.5	< 47098.2	< 150.8	Not in menu	< 50.3	3.5E+02	2.2E+02	2.6E+01
P	16			no07b08	< 1515.7	< 1894	8.68E+04	< 6385.7	< 32961.4	< 144.3	Not in menu	< 21.0	6.0E+02	4.5E+02	2.1E+01
P	5		Claithrate	no07a09	< 1536	< 3748.8	1.03E+05	< 11316.9	< 54132.1	< 177.2	Not in menu	< 45.2	2.3E+02	1.6E+02	< 7.4
P	7			no07a11	< 1302.3	< 1932.4	1.15E+05	< 7446.7	< 35873.9	< 155.2	Not in menu	< 35.1	2.3E+02	7.0E+01	6.7E+00
P	1			no07a05	< 770.3	< 1375	8.41E+04	< 7171	< 27801.4	< 96.3	Not in menu	< 27.1	6.8E+02	6.9E+02	1.2E+01
S	10			no07a14	7.7E+02	< 1411.2	8.08E+04	7.1E+03	< 24844.5	< 94.5	Not in menu	< 36.6	7.8E+02	1.2E+03	2.7E+01
S	11		Claithrate	no07a15	< 5466.5	< 10615.5	9.21E+04	< 27964	< 141630.8	< 499.1	Not in menu	< 163.2	1.5E+03	1.4E+03	1.3E+01

Table S2. LA-ICP-MS results for fluid inclusions from Northern Arkansas.

LA-ICP-MS Results (ppm)

NORTHERN ARKANSAS QUARTZ

Mode	Sample	Locality	Inc#	Size (x)	Size (y)	T _b (°C)	Salinity*	7Li	Na**	24Mg	35Cl	39K	43Ca	55Mn	65Cu	66Zn	81Br	88Sr	137Ba	208Pb
LOD VALUES IN RED for data below detection																				
	Lat. 36.13052 Long. 92.55152																			
P	NAMC 1B	Monte Cristo	1	108	23	123	2.31E+01	2.5E+01	8.2E+04	1.2E+00	1.40E+05	2.9E+03	1.5E+04	1.3E+00	<0.6	<0.3	8.1E+02	3.6E+02	1.2E+01	<0.8
P	NAMC 1B	Monte Cristo	2	34	25	123	2.31E+01	7.5E+00	8.5E+04	6.3E+00	1.40E+05	4.6E+03	8.3E+03	<2.6	<1.3	<0.6	<980	1.4E+02	6.8E+00	2.5E-01
P	NAMC-1 1A	Monte Cristo	1	44	28	110	2.35E+01	1.7E+01	8.2E+04	3.9E+00	1.43E+05	2.7E+03	1.7E+04	<1.0	<1.0	<0.4	<480	3.5E+02	1.7E+01	2.1E-01
P	NAMC-1 1A	Monte Cristo	4	53	44	108	2.32E+01	4.9E+01	7.6E+04	1.7E+01	1.41E+05	5.7E+03	2.2E+04	<4.0	<2.1	1.5E+00	<1550	3.6E+02	1.5E+01	9.6E-01
P	NAMC-1 1A	Monte Cristo	5	81	11	120	2.35E+01	1.3E+01	8.2E+04	1.5E+01	1.43E+05	2.7E+03	1.7E+04	<0.8	<0.5	<0.12	<340	4.9E+02	1.1E+01	3.9E-01
P	NAMC-1 1A	Monte Cristo	6	44	13	130	2.35E+01	8.3E+00	8.4E+04	8.8E+00	1.43E+05	3.1E+03	1.3E+04	<1.1	<0.7	<0.2	<370	2.7E+02	1.2E+01	5.0E-01
P	NAMC-1 1A	Monte Cristo	7	56	22	171	2.36E+01	1.5E+01	8.3E+04	8.7E-01	1.43E+05	3.6E+03	1.7E+04	5.9E-01	<0.3	1.9E-01	6.2E+02	5.0E+02	1.2E+01	<0.3
P	NAMC-1 1A	Monte Cristo	8	33	29	114	2.36E+01	<28.8	7.3E+04	1.1E+02	1.43E+05	1.8E+04	2.1E+04	<7.3	<4.5	1.6E+00	<3420	3.6E+02	1.1E+01	7.1E-01
P	NAMC-1 1A	Monte Cristo	9	44	12	112	2.36E+01	4.1E+01	7.7E+04	1.1E+02	1.43E+05	1.2E+04	1.9E+04	<3.9	<2.5	3.1E+00	<1280	6.9E+02	1.6E+01	1.1E+00
P	NAMC-1 1A	Monte Cristo	10	56	23	112	2.36E+01	1.3E+01	7.9E+04	5.7E+00	1.43E+05	6.1E+03	2.1E+04	<1.4	<0.7	<0.3	<5110	4.4E+02	2.7E+01	<0.6
P	NAMC-1 1A	Monte Cristo	11	41	17	115	2.32E+01	6.8E+01	7.6E+04	9.2E+02	1.41E+05	2.6E+04	1.0E+04	<10.0	<6.4	2.9E+00	<4340	2.1E+02	9.7E+00	<1.9
P	NAMC-1 1A	Monte Cristo	12	22	13	115	2.33E+01	<48.6	7.9E+04	2.3E+02	1.41E+05	1.8E+04	1.2E+04	<23.4	<17.5	<15.0	<9500	2.0E+02	<8.5	<1.6
P	NAMC-1 3	Monte Cristo	1	65	41	98	2.32E+01	2.0E+01	7.6E+04	5.6E+02	1.41E+05	6.8E+03	2.2E+04	<1.7	<1.8	6.4E+00	<0	4.9E+02	1.6E+01	6.5E-01
P	NAMC-1 3	Monte Cristo	2	47	23	100	2.32E+01	2.0E+01	7.8E+04	7.5E+02	1.41E+05	6.1E+03	2.0E+04	2.7E+00	<2.0	4.2E+00	<0	3.2E+02	1.4E+01	7.4E-01
P	NAMC-1 3	Monte Cristo	3	55	12	100	2.32E+01	1.5E+01	7.8E+04	8.8E+02	1.41E+05	4.9E+03	2.0E+04	<3.5	<3.4	<2.7	<0	2.7E+02	1.3E+01	1.1E+00
P	NAMC-1 3	Monte Cristo	4	41	32	100	2.33E+01	4.7E+01	6.4E+04	5.0E+01	1.41E+05	5.4E+03	3.9E+04	<4.7	<4.9	1.2E+01	<1170	5.2E+02	2.6E+01	8.6E-01
P	NAMC-1 3	Monte Cristo	5	39	28	103	2.33E+01	1.5E+01	8.1E+04	6.0E+02	1.41E+05	3.7E+03	1.7E+04	<3.8	<3.6	<3.0	<1250	2.3E+02	1.0E+01	5.4E-01
P	NAMC-1 3	Monte Cristo	6	48	16	100	2.30E+01	5.7E+01	6.8E+04	8.5E+02	1.40E+05	8.4E+03	3.1E+04	<2.4	<2.6	<1.8	7.8E+02	5.3E+02	2.5E+01	9.2E-01
P	NAMC-1 3	Monte Cristo	7	28	18	100	2.31E+01	<39.6	6.4E+04	2.2E+03	1.40E+05	1.0E+04	3.6E+04	8.2E+00	<33.7	<7.1	<1610	4.5E+02	2.8E+01	1.4E+00
P	NAMC-1 3	Monte Cristo	8	78	9	100	2.31E+01	6.3E+01	7.2E+04	8.6E+02	1.40E+05	6.7E+03	2.7E+04	<7.7	<8.0	<11.6	<2180	4.0E+02	1.9E+01	<1.8
P	NAMC-1 Chip 6	Monte Cristo	1	44	12	115	2.24E+01	2.6E+01	6.6E+04	5.6E+00	1.36E+05	9.2E+03	2.9E+04	1.8E+00	<1.5	<0.7	ND	8.3E+02	1.8E+01	<1.2
P	NAMC-1 Chip 6	Monte Cristo	2	28	24	116	2.23E+01	1.3E+01	7.9E+04	7.4E+00	1.35E+05	3.1E+03	1.5E+04	<4.0	<0.5	<0.3	<130	6.4E+02	7.4E+00	8.7E-01
P	NAMC-1 Chip 6	Monte Cristo	3	33	27	115	2.36E+01	2.0E+01	8.6E+04	9.1E+02	1.43E+05	3.0E+03	1.1E+04	7.5E-01	<0.2	1.2E+00	2.5E+02	5.3E+02	5.9E+00	5.3E-01
P	NAMC-1 Chip 6	Monte Cristo	5	65	15	120	2.34E+01	1.6E+01	8.7E+04	2.8E+00	1.42E+05	2.1E+03	8.4E+03	1.5E-01	<0.2	2.0E-01	1.6E+02	3.7E+02	5.8E+00	3.4E-01
P	NAMC-1 Chip 6	Monte Cristo	6	69	27	114	2.28E+01	1.6E+01	8.2E+04	1.5E+02	1.39E+05	3.2E+03	1.3E+04	8.3E-01	<0.2	3.6E-01	3.0E+02	4.1E+02	6.4E+00	3.6E-01
P	NAMC-1 Chip 6	Monte Cristo	7	26	23	111	2.26E+01	6.1E+01	6.8E+04	2.4E+02	1.37E+05	9.9E+03	2.7E+04	<2.5	<3.0	<1.3	<420	4.1E+02	2.0E+01	3.5E+00
P	NAMC-1 Chip 6	Monte Cristo	8	34	32	114	2.35E+01	3.5E+01	7.7E+04	<1.4	1.37E+05	1.9E+03	1.9E+04	<1.1	<1.3	5.0E+00	<180	4.5E+02	2.5E+00	6.7E-01
P	NAMC-1 Chip 2B	Monte Cristo	1	26	17	111	2.35E+01	1.1E+01	7.6E+04	1.1E+01	1.43E+05	5.4E+03	2.5E+04	<3.0	<2.1	<0.6	ND	5.6E+02	1.5E+01	6.7E-01
P	NAMC-1 Chip 2B	Monte Cristo	6	37	34	112	2.30E+01	2.2E+01	8.1E+04	9.2E-01	1.40E+05	2.9E+03	1.6E+04	3.6E+00	<0.9	9.7E-01	9.1E+02	5.3E+02	8.7E+00	9.1E-01
P	NAMC-1 Chip 2B	Monte Cristo	7	54	26	127	2.22E+01	<47.2	7.8E+04	<7.2	1.35E+05	4.6E+03	1.5E+04	<10.1	<5.9	<2.2	<2080	1.9E+02	4.6E+00	<0.8
P	NAMC-1 Chip 2B	Monte Cristo	2	72	18	115	2.29E+01	8.8E+00	8.5E+04	7.3E-01	1.39E+05	7.0E+02	8.6E+03	<0.3	1.4E-01	<0.1	1.5E+02	3.1E+02	3.5E+00	<0.02
P	NAMC-1 Chip 2B	Monte Cristo	3	44	23	104	2.29E+01	<9.0	7.8E+04	2.1E+00	1.39E+05	2.3E+02	2.1E+04	<1.3	<1.4	<0.2	5.4E+02	5.9E+02	1.0E+01	1.0E+00
P	NAMC-1 Chip 2B	Monte Cristo	5	54	31	112	2.30E+01	1.8E+01	7.9E+04	1.7E+00	1.40E+05	2.5E+03	1.2E+04	6.1E-01	<0.3	1.2E-01	6.1E+02	4.1E+02	6.6E+00	3.9E-01
P	NAMC-1 Chip 2B	Monte Cristo	9	44	12	112	2.30E+01	5.7E+01	7.2E+04	<3.4	1.40E+05	1.4E+04	2.2E+04	<5.1	<2.7	<1.2	<960	3.3E+02	6.2E+00	1.0E+00
P	NAMC-1 Chip 2B	Monte Cristo	10	117	16	110	2.30E+01	1.2E+02	6.4E+04	8.7E+02	1.40E+05	2.5E+04	2.6E+04	<9.4	<5.8	2.1E+00	<1690	4.2E+02	1.2E+01	<0.7

NORTHERN ARKANSAS SPHALERITE

Mode	Sample	Locality	Inc#	Size (x)	Size (y)	T _b	Salinity*	7Li	Na**	24Mg	35Cl	39K	43Ca	55Mn	65Cu	66Zn	81Br	88Sr	137Ba	208Pb
LOD VALUES IN RED for data below detection																				
Lat. 36.13052 Long. 92.55152																				
P	NAMC-1 Chip 2A	Monte Cristo	1	45	23	117	2.30E+01	4.7E+00	8.1E+04	1.29E+03	1.39E+05	2.4E+03	1.5E+04	8.0E+00	<1.2	ND	<1000	3.1E+02	1.4E+01	4.0E+02
P	NAMC-1 Chip 2A	Monte Cristo	2	34	12	105	2.29E+01	9.8E+00	8.0E+04	1.80E+03	1.39E+05	3.3E+03	1.6E+04	1.3E+01	<3.2	ND	<2310	6.6E+02	1.5E+01	2.6E+01
S?	NAMC-1 Chip 2A	Monte Cristo	3	109	22	109	2.30E+01	8.3E+00	7.7E+04	2.28E+03	1.40E+05	3.7E+03	2.1E+04	1.1E+01	<2.3	ND	<1990	4.3E+02	1.5E+01	3.5E+00
S?	NAMC-1 Chip 2A	Monte Cristo	4	43	31	110	2.30E+01	<8.9	8.0E+04	2.00E+03	1.40E+05	3.4E+03	1.7E+04	4.7E+00	<5.6	ND	<2340	3.7E+02	9.9E+00	1.6E+00
P	NAMC-1 Chip 2A	Monte Cristo	5	51	26	107	2.30E+01	6.6E+00	7.8E+04	2.05E+03	1.40E+05	3.8E+03	2.0E+04	8.1E+00	<5.9	ND	<2420	3.9E+02	1.3E+01	6.9E+01
P	NAMC-1 Chip 2A	Monte Cristo	6	23	19	111	2.30E+01	<9.3	8.0E+04	2.03E+03	1.40E+05	3.5E+03	1.8E+04	9.3E+00	<6.9	ND	<3830	4.1E+02	1.8E+01	1.0E+01
P	NAMC-1 Chip 2A	Monte Cristo	7	21	9	110	2.30E+01	<19.8	7.7E+04	1.99E+03	1.40E+05	4.9E+03	2.2E+04	<12.6	<15.7	ND	<7050	3.9E+02	2.0E+01	2.8E+01
P	NAMC-1 Chip 2B	Monte Cristo	1	37	23	110	2.32E+01	<11.7	7.9E+04	2.01E+03	1.41E+05	3.9E+03	1.9E+04	1.2E+01	<56.5	ND	<4800	3.2E+02	8.5E+00	<15.2
P	NAMC-1 Chip 2B	Monte Cristo	2	41	37	106	2.32E+01	<28.8	7.8E+04	2.23E+03	1.41E+05	4.4E+03	2.1E+04	<19.0	<132	ND	<8760	4.2E+02	1.7E+01	<45.7
P	NAMC-1 Chip 2B	Monte Cristo	3	44	23	99	2.34E+01	1.3E+01	7.6E+04	2.43E+03	1.42E+05	4.7E+03	2.5E+04	1.4E+01	<76.2	ND	<4230	4.3E+02	1.4E+01	5.1E+01
P	NAMC-1 Chip 2B	Monte Cristo	4	21	17	110	2.32E+01	<17.9	7.3E+04	2.25E+03	1.41E+05	4.1E+03	2.8E+04	<11.8	<132	ND	<5290	3.8E+02	1.1E+01	<35.6
P	NAMC-1 Chip 2B	Monte Cristo	5	49	23	110	2.30E+01	1.1E+01	7.4E+04	2.93E+03	1.40E+05	4.2E+03	2.6E+04	2.2E+01	<7.8	ND	<640	6.3E+02	2.0E+01	4.5E+01
Lat. 36.13290 Long. 92.54938																				
P	NAPA-1 1	Philadelphia	1	19	17	110	2.28E+01	<49.6	7.8E+04	1.60E+03	1.38E+05	3.6E+03	1.9E+04	<30.6	<13.0	ND	<6050	3.9E+02	<104	7.0E+01
P	NAPA-1 1	Philadelphia	1	40	11	118	2.28E+01	2.3E+01	7.0E+04	2.33E+03	1.38E+05	2.0E+04	1.9E+04	<21.1	<45.9	ND				
P	NAPA-1 1	Philadelphia	2	37	23	110	2.28E+01	<8.7	7.8E+04	1.37E+03	1.39E+05	1.3E+04	1.2E+04	<25.9	<16.3	ND	<7420	2.6E+02	1.1E+01	<10.8
P	NAPA-1 1	Philadelphia	3	35	21	110	2.27E+01	<28.3	7.5E+04	1.18E+03	1.38E+05	1.5E+04	1.6E+04	<21.1	<13.4	ND	<7700	3.1E+02	2.0E+01	<8.9
P	NAPA-1 1	Philadelphia	6	60	24	107	2.27E+01	<37.6	8.1E+04	1.23E+03	1.38E+05	7.6E+03	1.0E+04	<36.3	<69.5	ND	<13360	3.2E+02	9.6E+00	<5.6
Lat. 36.06556 Long. 92.74422																				
S?	NALD 1B 2	Lucky Dog	5	54	29	118	1.90E+01	1.2E+01	6.8E+04	1.11E+03	1.15E+05	2.7E+03	1.1E+04	1.2E+00	<1.2	ND	<900	7.6E+02	6.6E+00	8.6E+01
S?	NALD 1B 2	Lucky Dog	8	44	28	110	2.35E+01	1.2E+01	7.5E+04	1.48E+03	1.43E+05	8.8E+03	2.4E+04	5.2E+00	<1.7	ND	<1530	1.1E+03	3.3E+01	2.0E+00
P	NALD 1B 2	Lucky Dog	7	41	12	120	2.36E+01	<25.5	7.6E+04	1.28E+03	1.43E+05	1.8E+04	1.7E+04	<14.4	3.2E+01	ND	<9830	6.0E+02	2.6E+01	4.5E+01
P	NALD 1B 2	Lucky Dog	1	49	16	118	1.94E+01	3.7E+01	5.0E+04	2.05E+03	1.18E+05	1.3E+04	3.1E+04	<9.0	8.3E+00	ND	<9780	9.6E+02	1.3E+01	3.4E+01
P	NALD 1B 2	Lucky Dog	2	81	44	115	1.99E+01	1.4E+02	6.1E+04	5.3E+02	1.21E+05	<6180	1.2E+05	<189	3.7E+01	ND	<22600	4.3E+02	<309	1.3E+02
P	NALD 1B 2	Lucky Dog	3	45	41	115	1.94E+01	<61.6	5.9E+04	1.23E+03	1.18E+05	<42420	1.3E+05	<26.0	<28.3	ND	<15870	7.5E+02	1.9E+01	9.9E+01
P	NALD 1B 1	Lucky Dog	1	56	12	110	1.97E+01	6.7E+04	1.37E+03	1.19E+05	7.2E+03	1.4E+04	<11.9	<12.6	<90.0	ND	<8200	8.4E+02	8.6E+00	1.8E+02
P	NALD 1B 1	Lucky Dog	1	54	18	110	1.91E+01	<44.1	5.0E+04	3.17E+03	1.16E+05	1.0E+04	3.2E+04	<5.8	<7.6	ND	<4030	1.1E+03	2.4E+01	1.9E+01
P	NALD 1B 1	Lucky Dog	2	65	23	112	1.93E+01	<47.2	6.0E+04	2.11E+03	1.17E+05	<1040	2.3E+04	<62.7	5.0E+01	ND	<14670	8.0E+02	<22.2	2.4E+02
P	NALD 1B 1	Lucky Dog	3	53	47	112	1.93E+01	<27.2	6.2E+04	1.90E+03	1.17E+05	2.3E+03	2.3E+04	<16.6	<22.4	ND	<8100	6.4E+02	2.3E+01	8.5E+01
P	NALD 1B 1	Lucky Dog	4	34	18	131	1.94E+01	<61.5	5.9E+04	2.33E+03	1.18E+05	6.0E+03	2.4E+04	<40.7	<47.7	ND	<16270	7.8E+02	<24.9	<48.0
P	NALD 1B 1	Lucky Dog	5	88	34	127	1.93E+01	<34.9	5.5E+04	2.93E+03	1.17E+05	7.1E+03	2.9E+04	<15.8	2.7E+02	ND	<100	9.1E+02	2.4E+01	3.4E+01
P	NALD 1B 1	Lucky Dog	6	31	12	127	1.95E+01	<130.8	5.7E+04	3.26E+03	1.18E+05	9.5E+03	3.7E+04	<5.7	<6.2	ND	<28620	8.2E+02	8.6E+00	1.8E+02
P	NALD 1B 1	Lucky Dog	7	36	28	115	1.91E+01	<47.9	5.7E+04	2.12E+03	1.16E+05	7.7E+03	1.0E+05	<29.7	<40.0	ND	<10400	5.3E+02	3.2E+01	3.7E+02
S?	NALD 1B 1	Lucky Dog	8	124	41	115	1.95E+01	4.0E+01	5.4E+04	2.43E+03	1.18E+05	6.4E+03	3.1E+04	<6.8	<7.6	ND	<90	9.0E+02	1.6E+01	3.3E+00
P	NALD 1B 1	Lucky Dog	9	65	18	115	1.94E+01	<44.8	6.3E+04	2.2E+03	1.18E+05	3.2E+03	2.1E+04	<30.4	<33.0	ND	<10420	5.6E+02	<14.1	6.6E+01

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