Grey Knowledge

Embodied Expertise and the Problem of Invisible Loss

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ABSTRACT

Grey Knowledge names the embodied expertise held inside ageing bodies that no manual, database, or algorithm contains. It is the knowledge that blast furnace keepers carry in their eyes, that slate splitters carry in their hands, that mine deputies carried in their noses. It was never written down because it seemed obvious — the ordinary competence of people who simply knew what they were doing. When those people retire, are made redundant, or die, the knowledge does not transfer to a successor. It disappears. This paper establishes Grey Knowledge as a central theoretical concern of the Quantum Memory project, situates it within the thermodynamics of entropy and anti-entropy, examines its relationship to Heidegger's concept of ready-to-hand tool use, and provides a comprehensive taxonomy of roles in which this knowledge is most concentrated and most immediately at risk. It argues that the current wave of AI-driven automation represents a Grey Knowledge extinction event of historic proportions — and that the biological window for testimony is already closing.

I. NAMING THE PROBLEM

My grandfather John Clifford Watson died in 1960, aged fifty, above Ebbw Vale. He had worked underground his entire adult life. Whatever he understood about coal — how to read a seam, how to hear stress in rock, how to sense gas before any instrument registered it — died with him. Nobody thought to record it. It was not considered knowledge in any formal sense. It was simply what men in Cwm knew.

I did not discover this until I began researching the Quantum Memory project, and by then the knowledge was sixty years gone. There is nothing to recover. The archive is closed.

Grey Knowledge is the term I use for this category of expertise. It is knowledge that:

- resides in the body rather than in documentation
- was acquired through decades of practice in specific environments
- cannot be adequately transmitted through instruction alone
- was never recorded because it seemed self-evident to those who held it
- disappears entirely when its human carriers leave the workforce

The word 'grey' is deliberate. It carries two registers simultaneously. First, demographic: the people who hold this knowledge are, typically, in the later decades of their working lives. They

are the last generation trained in the old ways, before automation displaced the physical intelligence of their occupations. Second, epistemological: the knowledge itself occupies a grey zone between the explicit and the tacit, the documentable and the felt, the transmissible and the embodied.

> *This is not nostalgia. It is a diagnosis of an information loss event that is happening right now, at scale, across multiple industries, and accelerating as AI-driven automation moves up the skill register.*

The coalfields are already gone. The slate quarries survive only as heritage. But the steel industry, the compound semiconductor sector, the energy infrastructure, the healthcare system, the housing sector — these are all currently in the process of displacing experienced human judgment with algorithmic decision-making. The Grey Knowledge held by workers in these industries is not being archived. It is being retired, redundant, and in many cases simply not replaced.

The Quantum Memory project exists to interrupt this process — not to reverse it, which is impossible, but to create a record before the biological window closes entirely.

II. THEORETICAL FOUNDATIONS

Heidegger: The Ready-to-Hand

Martin Heidegger's distinction between present-at-hand and ready-to-hand provides the most precise philosophical vocabulary for understanding what Grey Knowledge is and why it is invisible.

A hammer used by a skilled carpenter is ready-to-hand: it disappears from conscious attention into the act of hammering. The carpenter does not think about the hammer. She thinks through it, toward the nail, toward the joint, toward the completed work. The tool's presence is a kind of absence — it has been absorbed into skilled practice.

The same structure applies to industrial expertise. A blast furnace keeper reading the colour of the tap does not consciously process the wavelength of the light. She knows, in the Heideggerian sense — knowledge that has been incorporated into her equipment-for-practice, not stored in her declarative memory. Ask her to explain what she is doing and she will struggle, not because she lacks intelligence, but because the knowledge exists below the level of articulation.

> *Only when the tool breaks does it become present-at-hand: visible, analysable, available for description. Grey Knowledge becomes visible only at the moment of its loss — the moment the furnace keeper retires and her replacement discovers, slowly, that something essential was never transmitted.*

This is the measurement problem as applied to industrial knowledge. The act of observation collapses the working state. You cannot fully document Grey Knowledge while it is operational, because documentation requires externalisation, and externalisation changes the form of the knowledge. What Quantum Memory can do is create the richest possible approximation — testimony, demonstration, contextualised description — before the opportunity disappears entirely.

Thermodynamics: Entropy and Anti-Entropy

The second theoretical register is thermodynamic. Systems tend toward entropy — toward disorder, homogeneity, the loss of complex structure. Industrial communities built extraordinary complexity over generations: networks of practice, chains of transmission, ecosystems of complementary expertise in which each role depended on and shaped the others. The pit deputy's gas detection informed the shot firer's placement. The rybelwr's reading of the slate grain informed the bargain setter's face allocation. These were not isolated skills but integrated systems of knowledge.

Post-industrial transition, from the perspective of information theory, is an entropy event. The complex knowledge structure dissolves. Its components are not reorganised into new structures — they are simply lost, along with the social infrastructure that sustained them.

Quantum Memory is explicitly conceived as an anti-entropy device. The RFID activation system — visitors triggering personal testimony at specific locations — is an attempt to hold complex information in structured relationship rather than letting it disperse. But the prerequisite for anti-entropy is the existence of something to preserve. The recording work must happen before the dissolution is complete.

The Automation Argument

There is a structural irony in the current AI moment that has not been sufficiently acknowledged. Machine learning systems are extraordinarily effective at codifying knowledge that has already been codified — at finding patterns in datasets that already exist. They cannot be trained on data that was never recorded. And Grey Knowledge, by definition, was never recorded.

This means that the AI systems displacing skilled workers in manufacturing, healthcare, energy and housing cannot actually replicate what those workers know. They can replicate the measurable outputs of skilled practice — the quality control pass rate, the diagnostic accuracy, the decision frequency — while being entirely blind to the underlying reasoning that generated those outputs. The algorithm learns to produce the same answers the experienced worker produces, for different reasons, with different failure modes.

> *You cannot train a neural network on data that was never recorded. The blast furnace keeper who reads the tap by colour and sound has no dataset. When she retires, that knowledge does not transfer to a machine. It simply disappears.*

The practical consequence is not that AI systems will fail immediately. It is that they will fail unpredictably, in situations that the experienced worker would have recognised and managed, because the experienced worker's recognition depended on a form of knowledge the system was never given. Grey Knowledge is the gap between algorithmic competence and genuine expertise — and as long as AI deployment continues faster than knowledge preservation, that gap widens with each retirement.

Quantum Memory: The Project Frame

The Quantum Memory project takes its name from a specific theoretical claim: that the knowledge held in the bodies of industrial communities exists, before its carriers die, in a superposition of states. It is simultaneously present (in the body of the worker) and absent

(from any retrievable record). It is, in the quantum mechanical sense, unmeasured — existing in multiple possible states until the moment of observation collapses it into a single outcome.

For Grey Knowledge, the measurement event is retirement, redundancy, or death. At that moment, the superposition collapses — not into a recorded state, but into nothing. The knowledge ceases to exist in any recoverable form.

The project's RFID activation system is an attempt to hold this knowledge in a more durable superposition: testimony preserved in layered audio, activated by visitors standing in specific locations, generating a form of presence for knowledge that its biological carrier can no longer provide. This is not resurrection. It is semantic encryption — the meaning held in the relationship between place, object, and voice, requiring all three to decrypt.

III. A TAXONOMY OF GREY KNOWLEDGE ROLES

The following taxonomy was developed in conjunction with the Quantum Memory scoping research, focused on the post-industrial communities of South and West Wales. It is not exhaustive. It is a working map of where Grey Knowledge is most concentrated, most specific, and most immediately at risk. The roles are organised by sector and region, following the five geographic areas the project intends to document.

In each case, the core question is the same: what does this person know that exists nowhere except inside them?

South Wales Coalfield

The knowledge held by coalfield workers is, in many cases, already irrecoverable. The last deep mines closed in the 1990s. Workers who were in their forties at closure are now in their seventies and eighties. The window is not closing — it has substantially closed. What remains is the testimony of those who are still alive, and it is fragmentary.

- **Collier / coal hewer —** the reading of a coal seam — its grain, its tendency, the sound of imminent movement
- **Pit deputy / fireman —** gas detection by smell and air movement before electronic monitors; roof assessment by the sound of supports under load
- **Winding engine operator —** the feel of rope weight and cage load that signalled fault before instruments registered it
- **Shot firer —** explosive placement calibrated by geological reading of the face, not calculation alone
- **Rope splicer —** hands-only jointing of steel rope under tension, a practice with no manual equivalent
- **Timberman —** underground structural intuition — reading stress in timber, sensing instability

Gwynedd Slate

The Welsh slate industry at its peak employed tens of thousands. The rybelwr — the slate splitter — is perhaps the purest example of Grey Knowledge in the British industrial tradition:

a skill that took years to acquire, that cannot be taught from a manual, and that produces results no machine has successfully replicated to the same standard. The few remaining practitioners are elderly.

- **Rybelwr (splitter) —** splitting slate along the grain by feel and sound — the tap of the mallet, the give of the stone, knowledge in the fingertips
- **Naddwr (dresser) —** trimming slate to exact gauge by eye and hand, with tolerances that instruments confirm but cannot produce
- **Bargain setter —** reading a rock face for its geological history, allocating face sections to workers based on accumulated pattern recognition
- **Incline operator —** controlling loaded wagons on steep gradients by the feel of the brake — embodied physics
- **Quarry powder man —** reading the face before a blast, assessing yield and fragmentation by sight alone

Port Talbot and South Wales Steel

This is the most urgent section. As of 2024, Tata Steel's Port Talbot blast furnaces have been decommissioned, with electric arc furnace transition underway. Workers who spent careers reading the furnace are being made redundant right now. The Grey Knowledge of Welsh steelmaking is at acute and immediate risk of total loss.

- **Blast furnace keeper —** reading the colour and behaviour of the tap to assess melt quality — a visual and olfactory reading that no instrument replicates exactly
- **Rolling mill operative —** predicting steel behaviour in the rolling mill from feel, sound, and visual cues — preventing disasters that models would not anticipate
- **Basic oxygen steelmaking operator —** managing the timing and composition of the converter charge by accumulated physical intuition
- **Shift charge engineer —** whole-plant pattern recognition across dozens of simultaneous variables — safety judgments made in seconds from embodied familiarity
- **Maintenance fitter / millwright —** fault diagnosis by vibration, sound, and smell before instruments confirm
- **Teeming crane operator —** managing the ladle and the pour by feel, timing, and visual judgment

Advanced Manufacturing: Newport–Bridgend Corridor

The semiconductor and advanced manufacturing cluster in South East Wales represents a different category of Grey Knowledge — more recent in its formation, but no less embodied for that. These workers are typically in their forties and fifties, which means the window is open but not wide. AI-driven quality control systems are already being deployed in facilities where experienced operators' tacit knowledge has never been formally captured.

- **Semiconductor wafer inspector —** visual and tactile inspection of wafers that algorithms now replicate — but experienced operators identify fault signatures the algorithm has never been trained to see
- **Compound semiconductor process technician —** micro-adjustment of growth conditions in response to subtle environmental signals — knowledge below the threshold of formal documentation
- **PCB assembler / hand solder technician —** hand soldering of complex assemblies, with spatial memory of component behaviour that no training manual encodes

- **Precision machinist (pre-CNC) —** setting and reading manual lathes — knowledge that disappears as CNC replaces the machines that required it
- **Calibration technician —** knowing when an instrument is drifting before it fails — an anticipatory competence built from years of pattern exposure
- **Experienced quality control inspector —** the integration of decades of quality signals into rapid visual assessment — what cannot be measured but is consistently right
- **Tool and die maker —** making the tools that make the parts — a meta-level craft disappearing as single-use tooling replaces reground and adapted stock

Energy Infrastructure: Pembroke, Aberthaw, Milford Haven

The Welsh energy transition is dismantling one knowledge ecology and building another. The workers who ran Aberthaw B — a 1.56 GW coal power station — held integrated knowledge of a specific complex system that no longer operates. Their successors in offshore wind and gas peaking plants face different problems with different tools. The translation is incomplete and the gap is rarely acknowledged.

- **Power station control room operator (Aberthaw) —** reading the behaviour of the plant through analogue instruments — whole-system situational awareness built from decades of familiarity with one specific facility
- **Oil refinery process operator (Milford Haven) —** reading flow, pressure, and temperature by feel and sound before digital SCADA systems became primary
- **LNG terminal operator —** cryogenic handling knowledge developed through physical exposure — sensing temperature differentials that instruments confirm but experience navigates
- **Turbine maintenance engineer —** reading vibration and wear by touch and sound — maintenance based on embodied diagnosis rather than scheduled replacement
- **Cable jointer —** underground and submarine cable splicing by hand — a specialism where the knowledge exists in tactile memory
- **Electrical foreman —** reading a whole electrical system's behaviour through accumulated pattern — anticipatory fault recognition

Healthcare: The NHS Knowledge Ecology

Healthcare Grey Knowledge differs from industrial Grey Knowledge in one important respect: it is being actively lost through both retirement and AI deployment simultaneously, with the additional dimension that its loss has immediate consequences for patient safety. The experienced radiographer, the long-serving district nurse, the psychiatric nurse with thirty years of ward knowledge — these are all carriers of Grey Knowledge that AI systems are being asked to replicate without ever having been given access to it.

- **Radiographer (experienced) —** seeing what the algorithm flags as normal — pattern recognition built from decades of anomaly exposure that no training set encodes
- **District nurse / community psychiatric nurse —** hearing from the tone of a voice or the rhythm of a sentence that a disclosure is coming — anticipatory social cognition built from thousands of consultations
- **Ward sister (experienced) —** reading a patient's trajectory through subtle physical and behavioural signals before any instrument registers change
- **GP (long-serving) —** the long-term knowledge of a practice population — the ability to read a new presentation in the context of a multi-year relationship
- **Senior midwife —** reading a labour's progress by feel, sound, and maternal behaviour — integrated sensory assessment that no monitor fully replaces

Social Infrastructure: Housing, Education, Community

The final category is perhaps the most invisible because it has never been associated with industry at all. But the knowledge held by experienced housing officers, long-serving teachers, community development workers, and social workers is Grey Knowledge in every structural sense: embodied, tacit, contextual, and at immediate risk of loss as workforces age, are restructured, and are partially replaced by automated triage systems.

- **Housing caseworker (experienced) —** knowing from the tone of a phone call that a disclosure is coming; reading the subtext of a repair request for signs of crisis
- **Long-serving schoolteacher —** the full-school knowledge that allows a teacher to read a class, anticipate conflict, notice the child who needs intervention before the incident
- **Community development worker —** the network knowledge of a community — who connects to whom, where the latent leadership sits, how institutional trust was damaged and how it might be rebuilt
- **Experienced social worker —** reading a family system rapidly and accurately — anticipatory assessment based on pattern recognition across hundreds of similar cases
- **Long-serving community police officer —** knowing the informal rules of the neighbourhood, the history that explains the present, the relationships that hold the formal system together

IV. THE QUANTUM MEMORY METHODOLOGY

If Grey Knowledge is the problem, testimony is the intervention. But not testimony in the conventional sense — the subject sitting in front of a camera explaining what they did. That approach produces the externalised, present-at-hand version of the knowledge: the description of the skill rather than the skill itself. It is necessary but insufficient.

The Quantum Memory methodology attempts to capture the context of Grey Knowledge alongside its content: the place where it was exercised, the physical relationships it depended on, the sensory environment in which it made sense. The RFID activation system places testimony at specific locations — at the furnace, at the face, at the control room — so that the act of presence at the site partially reconstitutes the conditions under which the knowledge operated.

The collaboration with Robin Rimbaud (Scanner) extends this approach into the sonic register. Rimbaud's practice of making audible the invisible transmission layers beneath everyday life — intercepted signals, hidden frequencies — is formally aligned with Grey Knowledge's own invisibility. The sound design does not illustrate the testimony: it creates an acoustic field in which the testimony can be heard as it was originally felt.

> *The installation does not ask visitors to imagine what it was like. It attempts to create the conditions — spatial, acoustic, tactile — in which some residue of the original knowledge might still be felt. This is not reconstruction. It is anti-entropy: holding complex structure in being a little longer.*

The Heritage Advisory Groups established for the project — one in each of the five regions — are integral to the methodology rather than peripheral to it. They are the networks through which carriers of Grey Knowledge are identified and reached. And they are themselves a form

of Grey Knowledge infrastructure: the community knowledge of who knows what, where the expertise lives, whose testimony matters.

Dave Snowden's involvement as a collaborator brings the Cynefin framework — the complexity-based sense-making methodology — into the project's analytical structure. Snowden's insistence that complex knowledge cannot be managed through command-and-control approaches, and that it can only be elicited through narrative and context rather than questionnaire and procedure, is directly relevant to both the interview methodology and the installation's activation logic.

V. THE BIOLOGICAL WINDOW

This paper has used the phrase 'biological window' several times. It requires direct explanation.

Grey Knowledge is held in bodies. Bodies age, become ill, and die. This is not a metaphor. It is a material constraint on what it is possible to recover.

For the South Wales coalfield, the window is substantially closed. Workers who had developed deep expertise at the time of the last pit closures (1985–1995) were in their thirties and forties then. They are in their sixties to eighties now. Some are still available for testimony. Many are not.

For steelmaking, the window is open but closing fast. The Port Talbot redundancies of 2024 put workers in their forties to sixties out of the industry with their knowledge intact. Some of these people are still in the region, still able and willing to give testimony. The window here is perhaps a decade.

For semiconductor and advanced manufacturing, the window is wider — workers in their forties and fifties, knowledge acquired in the 1990s onward. But AI deployment in these sectors is accelerating, which means the knowledge may be displaced before the workers who hold it reach retirement age.

For healthcare and social infrastructure, the situation is ongoing and urgent in a different way: the knowledge is being lost through workforce restructuring, deskilling, and turnover rather than through retirement alone. The experienced ward sister who leaves because conditions have become unworkable takes her knowledge with her.

> *The thermodynamic argument is simple: entropy increases over time. The complex structure of embodied expertise disperses. The Quantum Memory project is an intervention in that dispersal, and like all anti-entropy interventions, it requires energy — and time.*

This is why the Arts Council Wales R&D application is framed around urgency rather than desirability. The project is not about creating something that would be nice to have. It is about preserving something that will otherwise be lost before we fully understand its value.

VI. PERSONAL ARCHAEOLOGY

I should be explicit about my own position in this work.

I was born on 25 December 1958. The tooth enamel I was growing in 1961 contains elevated Carbon-14 from atmospheric nuclear testing — the Bomb Pulse, which peaked in 1963 and has been declining since. My body is a historical document in a literal, isotopic sense. I carry the signature of a specific moment in human history inside my teeth.

This is not a detail I cite for effect. It is central to the project's phenomenological grounding. The Quantum Memory project argues that bodies hold knowledge that no external record contains. My own body makes that argument in the most concrete possible way.

The discovery that my maternal grandparents are buried above Ebbw Vale — John Clifford Watson, dead at fifty in 1960 — transformed the project from academic documentation to personal archaeology. Whatever my grandfather knew about coal, he took with him. I cannot recover it. But I can ensure that the same thing does not happen, on my watch, to the generation of industrial workers who are still alive.

My own career has been a form of embedded participant observation across British institutional transformation: job centres in the Thatcher recession, the Clays Lane Housing Co-operative before the Olympic erasure, military photography across Cold War garrisons and active theatres, the dot-com infrastructure boom and collapse, housing association management in post-industrial Wales. Forty years of watching institutions created with genuine community purpose transform under extraction logic.

> *The through-line of that observation is this: the institutions did not betray the communities they served. They never saw them. The people in them, with their embodied knowledge and their complex social intelligence, were invisible to the administrative systems that managed them.*

Grey Knowledge is the name for what those administrative systems could not see. Quantum Memory is an attempt to make it visible, before the last opportunity passes.

CONCLUSION

Grey Knowledge is not sentimental. It is not an argument for returning to conditions of physical danger and economic precarity. The coal mines are closed for good reasons. The slate quarries that consumed men's lungs are heritage sites for good reasons. The question is not whether the industries should have survived. It is whether the knowledge they generated — at such cost, over such time — should be allowed to disappear without record.

The answer, I think, is no. And the reason is not preservation for its own sake but relevance for the future. The patterns of expertise embedded in these workers — the ability to read complex systems through embodied familiarity, to make rapid high-stakes decisions from tacit knowledge, to hold multiple variables in simultaneous relationship without formalising them — are precisely the capacities that AI systems lack. They are not relics. They are the leading edge of what human cognition can do that machine cognition cannot yet replicate.

If we lose them without record, we lose the evidence base for understanding what we have lost. And in losing that, we lose the ability to ask the right questions of the systems that are replacing them.

> *Quantum Memory is not a memorial project. It is a research project. The difference matters. A memorial marks what is gone. Research asks what it means that it is gone — and what we should do about it.*

The Grey Knowledge taxonomy in this paper is not a catalogue of the past. It is a map of what is still available for testimony, if we move quickly enough.

The biological window is open.

This is the work of now.

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