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## From Emblems to Administrative Media: Reassessing the Social and Economic Functions of Indus Seals

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**Abstract:**Indus or Harappan seals have often been interpreted as artworks, ownership marks, merchant devices, badges of authority, ritual objects, or material witnesses to an undeciphered script. This article reassesses their social and economic functions by treating seals not as isolated icons but as components of a wider documentary ecology: the linked assemblage of seals, sealings, tablets, tags, standardized weights, containers, storerooms, gates, workshops, and interregional exchange practices through which information was made durable and authority was made visible. The article does not propose a decipherment. Instead, it develops an evidence-weighted synthesis of excavation reports, seal corpora, contextual studies, inscriptional statistics, iconographic analysis, and comparative work on sealing systems. The central argument is that no single-function model can account for the corpus. The strongest evidence supports administrative closure control, storage regulation, access management, and regulated exchange, especially where impressed clay sealings preserve reverse impressions of cords, jars, bags, doors, boxes, mats, or locking devices. Moderate evidence supports social or official identity through portable seals, perforated bosses, and repeated motif-inscription pairings. Selected narrative, composite, and deity-like motifs point to symbolic authority, but this authority probably reinforced rather than replaced practical control. By separating object classes and by distinguishing strong direct evidence from moderate contextual evidence and weaker semantic hypotheses, the article offers a cautious, testable model of Indus seals as institutional media within a decentralized but highly standardized urban civilization.

**Keywords:** Indus Civilization; Harappan seals; sealings; Indus script; administrative archaeology; economic regulation; glyptics; Bronze Age South Asia; documentary ecology; material bureaucracy

### I. Introduction

The seals of the Indus or Harappan Civilization are among the most recognizable artifacts of Bronze Age South Asia, yet their functions remain difficult to define securely. A typical Mature Harappan square stamp seal combines an animal motif, a short sign sequence, a repeated object placed before the animal, and a perforated boss on the reverse. Each feature is meaningful in relation to the others, but none can be interpreted in isolation. (Figure 1) The script remains undeciphered; many inscriptions are brief; and a substantial part of the legacy corpus lacks precise archaeological context. These conditions require an interpretive strategy that begins with material procedure rather than with presumed semantic readings [1]-[5].

Earlier scholarship has often privileged one function at a time. Seals have been treated as commercial devices, ownership marks, amulets, symbols of rank, or sources for script decipherment. Each approach identifies an important dimension of the evidence, but each becomes misleading when generalized to the whole corpus. Sealings with impressions of cords, jars, mats, bags, doors, boxes, or locking devices provide a different class of evidence from a carved seal alone. Perforated bosses support the possibility of carrying, wearing, or suspending seals, but they do not prove that every seal was a personal brand. Narrative and deity-like images are significant, yet they form only a subset of the corpus. The question is therefore not to discover one single meaning, but to reconstruct the procedures through which seals were made, carried, impressed, recognized, stored, broken, and discarded.

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Earlier scholarship has often privileged single-function explanations of Indus seals, including commercial branding, ownership marking, ritual or amuletic use, or as inputs for decipherment-oriented approaches. Each of these traditions captures a partial dimension of the evidence, but becomes reductive when extended to the entire corpus.

A. Unicorn stamp seal and modern impression (The Met 49.40.1)



B. Buffalo stamp seal (The Met 49.40.2)



**Figure 1. Standard Mature Harappan stamp-seal format represented by unicorn and buffalo examples. Source: public-domain Metropolitan Museum of Art objects 49.40.1 and 49.40.2, reproduced in the working manuscript.**

A key limitation across these models is that they tend to treat seals as isolated signifiers rather than as components of operational procedures. By contrast, sealing evidence, closure traces, standardized weights, and controlled architectural spaces indicate that seals functioned within coordinated systems of access control, authorization, and exchange. Perforated bosses further indicate portability and embodied use, but do not reduce seals to individual property markers. Likewise, symbolic and narrative motifs constitute an important subset of the corpus, but cannot account for the full range of sealing practices.

This study therefore shifts the analytical focus from “what seals mean” to “what seals do,” reconstructing the procedural chain through which seals were produced, carried, impressed, recognized, archived, and discarded. It advances a documentary-ecology model in which seals, sealings, tablets, tags, weights, containers, storerooms, gates, workshops, and inscriptions form an integrated system of material information processing [1], [19].

Compared to earlier approaches, the present framework differs in three respects: it treats seals as operational media embedded in practice; it explicitly grades claims according to evidentiary strength rather than interpretive plausibility; and it incorporates regional and interregional variability, avoiding both excessive uniformity and over-fragmentation of the Indus system.

## 2. Materials, Source Selection, and Evidence-Weighting Method

This study offers a critical synthesis rather than a new excavation report. Its evidentiary base comprises primary excavation reports and corpora, site-specific contextual studies, peer-reviewed archaeological and inscriptional research, museum records, and recent methodological work in imaging, archaeometry, and digital humanities. Sources were included when they preserved object class and archaeological context, provided reproducible typological, inscriptional, or technological analysis, or clarified the methodological limits of functional interpretation. Evidence was assigned lower weight when provenance was uncertain, object definitions were inconsistent, or interpretation depended primarily on unverified readings of the undeciphered script. Primary reports and corpora are given greatest evidentiary weight when they connect an object to site, phase, locus, material, dimensions, and associated finds. Contextual studies are used to assess procedure, spatial patterning, and variation. Museum records support object description, dimensions, and image attribution, but are not treated as sufficient for corpus-level statistical inference. Digital and computational studies are used only where their claims about sign structure, image recognition, or production can be related back to archaeological metadata.

The method follows four principles. First, object classes are kept analytically distinct. A seal is a portable instrument capable of producing impressions; a sealing is the archaeological trace of an impressed closure; a tablet may circulate independently of closure; a tag may have been attached to a bundle or container; and graffiti or pot marks may be

informal, secondary, or locally specific. Collapsing these categories risks transferring evidence for one practice onto another. These object-class distinctions are summarized in Figure 2, which provides a schematic overview of the functional and evidentiary separation between seals, sealings, tablets, tags, and graffiti/pot marks.

Analytical distinction among object classes prevents evidence for one practice from being transferred to another.






1	Seal	2	Sealing	3	Tablet	4	Tag / pendant	5	Graffiti / pot mark
									
Definition / material character	portable intaglio instrument, often with perforated boss	Definition / material character	archaeological trace of an impressed closure	Definition / material character	small sign-bearing object, independent of closure	Definition / material character	attached or suspended object moving with goods or persons	Definition / material character	mark on pottery or another surface, often secondary or local
Direct evidentiary value	authorization, identity, classification, display – as potential functions	Direct evidentiary value	strongest evidence for closure, access control, monitoring	Direct evidentiary value	possible accounting, classification, rationing, licensing, ritual use	Direct evidentiary value	possible bundle tag, pass, delivery marker, controlled movement	Direct evidentiary value	possible ownership, batch, contents, route, workshop, ritual marking
Caution	seal alone does not prove actual closure use	Caution	survival is uneven; interpretation depends on secure context	Caution	function must not be inferred from seals or sealings alone	Caution	requires attachment, wear, or contextual evidence	Caution	often informal; not equivalent to seal inscriptions

Figure 2. Object-class distinctions required for functional interpretation. Source: by author

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### 3. Corpus, Typology, Materials, and Manufacture

The canonical Mature Harappan seal is a small square stamp seal, usually made of steatite, carved in intaglio, and fitted with a perforated boss on the reverse. Its face commonly combines a short inscription, an animal motif, and a repeated object placed before the animal. Because steatite could be carved while relatively soft and then fired or treated to produce a harder, paler surface, the seal was durable, portable, and suitable for repeated impression-making. It was therefore not merely an image-bearing object, but an instrument designed for repeatable action [2], [10].

The corpus, however, is typologically diverse. Although square stamp seals dominate the Mature Harappan repertoire, rectangular bar seals, button seals, faience and terracotta examples, rare metal examples, Gulf-type seals, tablets, tags, pendants, and later regional forms complicate any single functional interpretation. Early sealing practices and regional variants further show that marking, suspension, and symbolic identification preceded and outlasted the mature urban square seal. Functional analysis must therefore distinguish object classes rather than treating all sign-bearing objects as equivalent. Table 1 summarizes the main object classes considered in this study and identifies the functional implications and interpretive limits attached to each.

Table 1. Object classes, material affordances, and functional implications.

Object class	Material or formal affordance	Main functional implication	Interpretive caution
Seal	Portable intaglio tool, often	May have served in authorization,	A seal alone does not prove

Object class	Material or formal affordance	Main functional implication	Interpretive caution
	with a perforated reverse boss.	identification, classification, controlled access, or display.	actual use on closures.
Sealing	Clay impression applied to, or pressed against, a closure.	Provides the strongest evidence for closure control, access monitoring, and authorization.	Survival is uneven, and interpretation depends on secure archaeological context.
Tablet	Small sign-bearing object, often independent of a closure.	May relate to accounting, classification, rationing, licensing, exchange, or ritual practice.	Its function cannot be inferred directly from seals or sealings.
Tag or pendant	Suspended or attachable object, sometimes movable with goods or persons.	May have marked bundles, containers, deliveries, permissions, or controlled movement.	Requires attachment, suspension, wear, or contextual evidence.
Graffiti or pot mark	Mark placed on pottery or another surface, often secondarily.	May indicate ownership, batch, contents, route, workshop, or ritual marking.	Often informal or local and should not be equated with seal inscriptions.

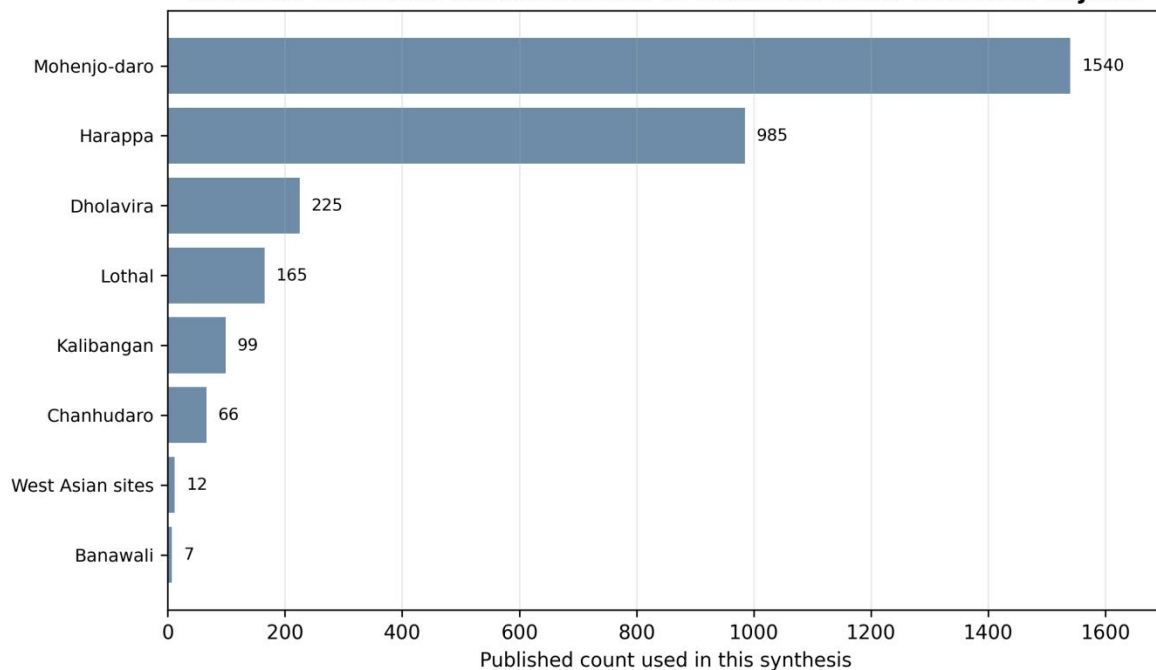
Manufacture provides a further link between form and function. Microtopographic analysis indicates that seal carving followed ordered sequences of engraving actions. Variation in carving sequence may identify individual carvers or communities of practice, suggesting that seals were produced within specialized craft traditions rather than as casual or incidental objects [10]. Such organization is consistent with institutional demand, although it does not by itself prove centralized bureaucracy.

The reverse boss is especially significant because it allowed many seals to be suspended, carried, worn, or stored in controlled settings. A seal could therefore function simultaneously as a technical instrument and as an embodied sign of identity or office. It could authorize a closure while also marking the bearer as socially recognized. This dual affordance connects economic procedure with social identity and cautions against separating practical and symbolic functions too sharply [9].

#### 4. Distribution, Concentration, and Publication Bias

Distributional evidence is essential but methodologically fragile. Legacy corpora give high counts for Mohenjo-daro and Harappa and smaller counts for Dholavira, Lothal, Kalibangan, Chanhudaro, Banawali, and West Asian contexts. These values show that seals and inscribed objects cluster strongly at major urban centers and selected production or trade sites. They do not, however, directly measure the ancient frequency of seal use. They are shaped by excavation history, preservation, collection practices, publication priorities, and changing object definitions [4]-[8].

**Selected Published Concentrations of Indus Seals and Inscribed Objects**



**Figure 3. Selected published concentrations of Indus seals and inscribed objects. Source: values compiled from published counts discussed in the manuscript; the chart is publication-weighted and not directly additive.**

Dholavira illustrates the risk of equating publication counts with ancient frequency. Earlier corpus listings underrepresented the site, whereas later reporting documented a much richer assemblage of seals and sealings [6]. The difference reflects archaeological visibility and publication history rather than a change in ancient importance. For this reason, count charts should be described as publication-weighted evidence, not as statistically complete populations.

Even with these cautions, the broad pattern is meaningful. Seals are not evenly distributed domestic trinkets. They are disproportionately associated with large urban centers, trade or craft settlements, and contact zones where goods, labor, identity, and access required coordination. This conclusion becomes stronger when distribution is combined with sealing evidence, standardized weights, workshops, storage areas, and gates. Distribution alone is moderate contextual evidence; distribution plus preserved use traces can become strong evidence for specific administrative procedures.

#### 5. Sealings, Closure Systems, and Administrative Procedure

The strongest evidence for seal function comes from sealings. A seal suggests potential use; a sealing records use in action. Clay sealings with reverse impressions of cords, mats, jars, bags, doors, boxes, or locking devices show that seals were impressed into clay to secure or authenticate closures. This evidence shifts interpretation from isolated iconography to procedure. A sealing relates a seal, clay, a closure medium, an object or space, and an action. It therefore records a moment at which a physical closure became socially monitored [3], [11], [12].

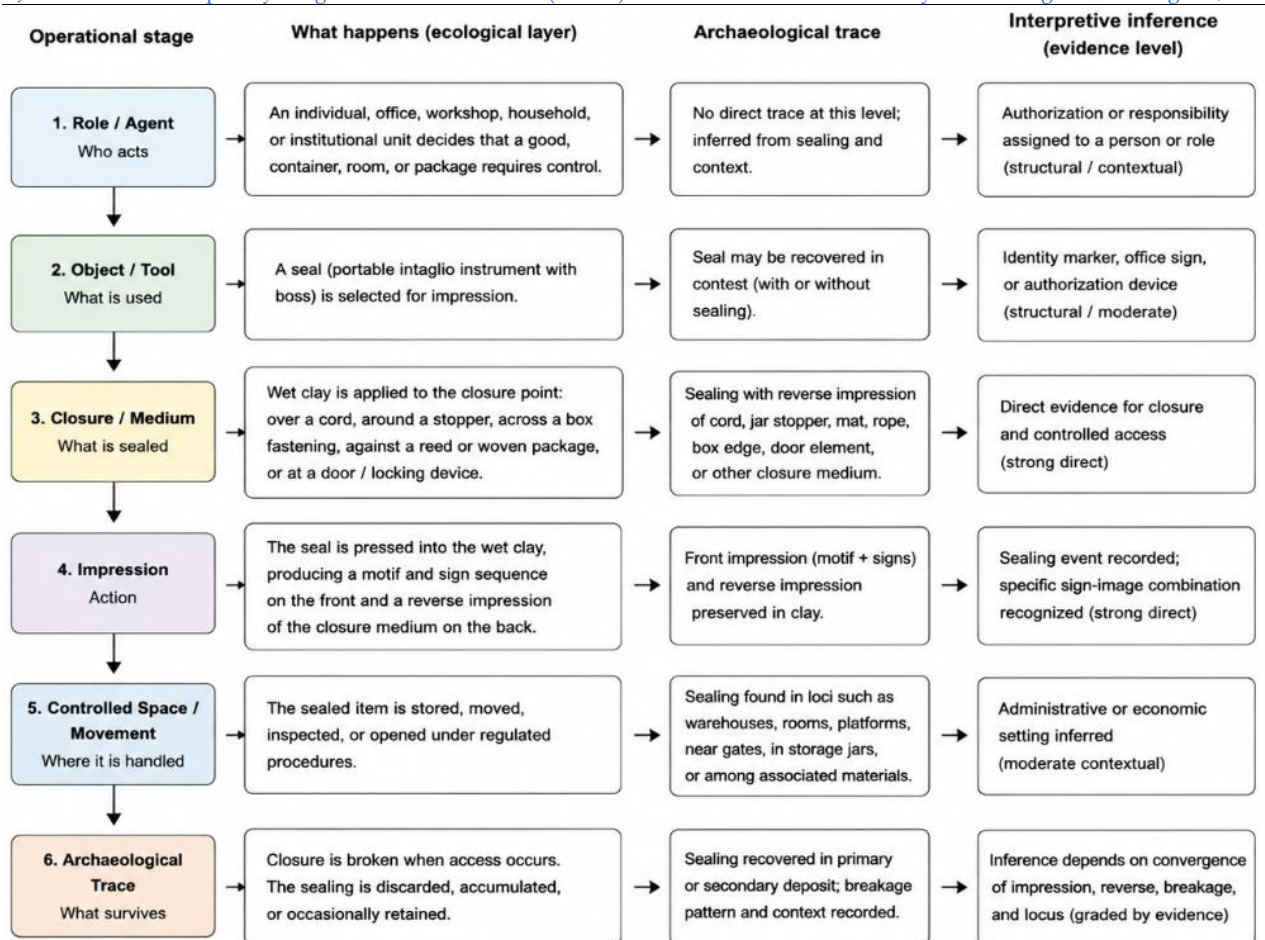
Lothal is a crucial example because its sealing assemblage has been interpreted not simply as transit labeling but also as evidence for storehouse or warehouse management. Sealings that preserve traces of doors, bags, jars, reed or woven packages, wooden boxes, and locking arrangements indicate that sealing was adaptable to multiple media. The administrative significance lies not in any single commodity but in the repeated procedure of authorized closure. Harappa provides complementary evidence through inscribed objects, sealing tags, standardized weights, and better contextualization from later excavations [5], [11], [12].

#### 5.1. A Lothal walk-through: from closure to archaeological inference

The documentary-ecology model becomes clearest when followed through an operational example. The following walk-through is deliberately procedural: it synthesizes the kinds of evidence reported for Lothal sealings rather than claiming that a single surviving object preserves every step. A package, jar, box, or room selected for control would first be measured, bundled, closed, or otherwise prepared for restricted access. Wet clay would then be applied to the closure point: over a cord, around a stopper, across a box fastening, against a reed or woven package, or at a door or locking device. A seal would be pressed into the clay, leaving a motif and sign sequence on the front and a reverse impression of the closure medium on the back. The sealed item could then be stored, moved, inspected, or opened. When access occurred, the closure would be broken and the sealing either discarded, accumulated, or retained. Archaeologically, the strongest inference comes when the front impression, reverse impression, breakage pattern, and locus converge. As shown in Figure 4, this sequence can be understood as a movement across ecological layers—role, object, closure, controlled space, archaeological trace, and graded interpretation—thereby linking operational procedure to evidentiary evaluation.

This example also clarifies the distinction between strong and moderate evidence. If a sealing preserves the reverse impression of a cord or jar stopper, it is strong direct evidence for closure control. If the same sealing is found in a room interpreted as a warehouse, the warehouse interpretation is moderate contextual evidence unless the spatial association is secure and recurrent. If a researcher argues that the signs name a commodity or tax, that claim remains a semantic hypothesis unless supported by independent evidence. The hierarchy does not weaken the argument; it prevents different evidentiary levels from being confused.

Preservation bias must remain central. Clay sealings survive only under certain conditions, while cords, cloth, wooden doors, bags, and many containers disappear. The record probably underrepresents sealing practice. Conversely, the presence of carved seals without sealings at a site does not prove that identical closure procedures existed there. Direct sealing evidence is high-confidence when present, but absence of evidence should be interpreted cautiously.



**Figure 4. Lothal sealing walk-through.** The example shows how a sealing moves through ecological layers: role, object, closure, controlled space, archaeological trace, and graded interpretation. Source: by author

## 6. Economic Regulation, Measurement, and Controlled Exchange

Economic interpretations are strongest when seals are connected to controlled space, standardization, and metrology rather than to a generalized idea of trade. The Indus world is well known for standardized weights, craft specialization, planned settlements, and long-distance contacts. Seals belong within this wider field of standardization. They were one administrative interface among several rather than the only instrument of control [1], [19].

The relationship between seals and weights is particularly significant. Weights make quantity comparable; seals make authorization repeatable. A transaction involving stored goods, craft output, transport, rationing, or access control could require both measurement and approval. The seal did not weigh the goods, and the weight did not identify the authorizing role. Together, however, they could support procedures in which goods were measured, marked, transferred, checked, and made accountable.

Taxation, craft licensing, rationing, and access-control interpretations are plausible because seals and sign-bearing objects occur in contexts associated with gates, workshops, public buildings, weights, and storage. These interpretations should nonetheless be expressed as models rather than established facts. A gate context may imply controlled movement, but the exact rule being enforced cannot be read directly. A workshop context may imply regulated production, but it does not automatically identify a guild, tax office, or individual artisan [13], [14].

At the local scale, seals could regulate access to rooms, stores, containers, or packages. At the urban scale, they could help coordinate workshops, gates, and public buildings. At the regional scale, repeated formats could support recognition across settlements. At the interregional scale, seals and seal-related objects could participate in exchange networks where Indus identity and administrative technology were recognized, imitated, or transformed.

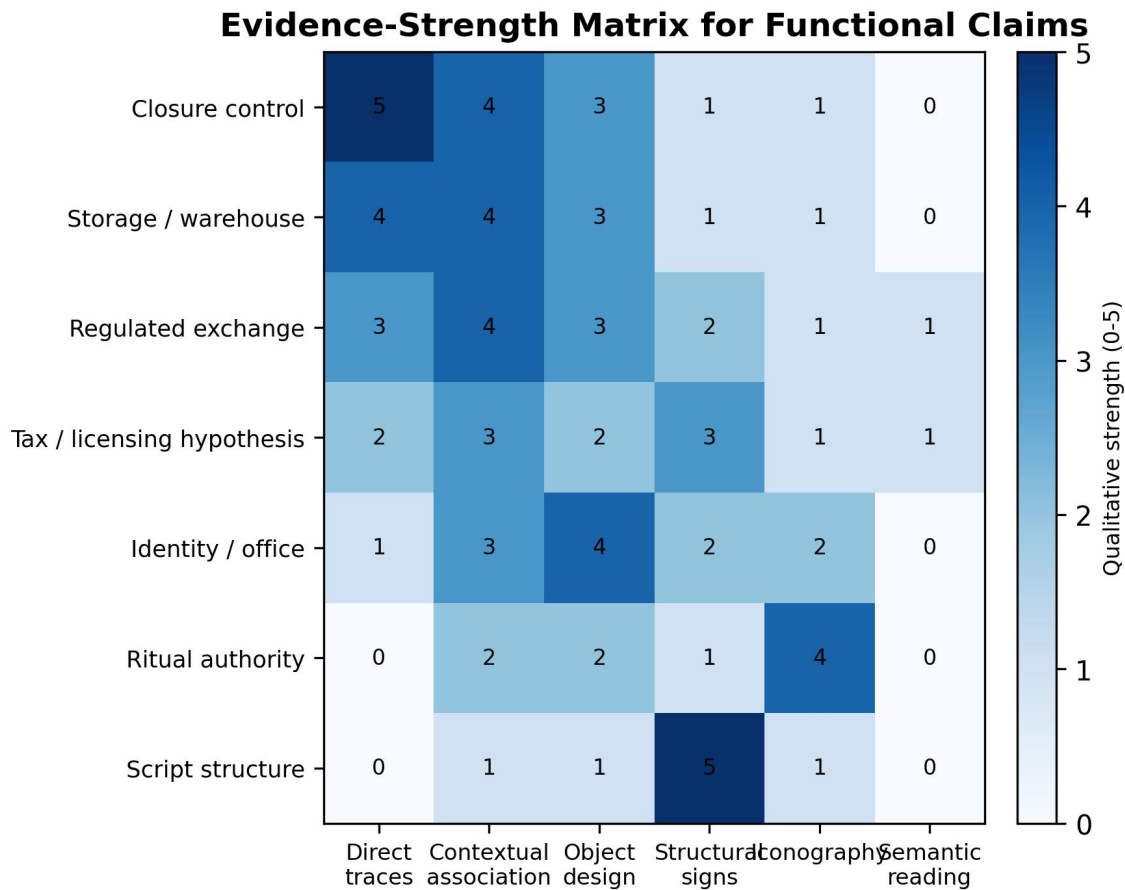


Figure 5. Evidence-strength matrix for functional claims. Source: authorial qualitative synthesis based on the evidence hierarchy in Section 2.

### 7. Social Identity, Office, and Symbolic Authority

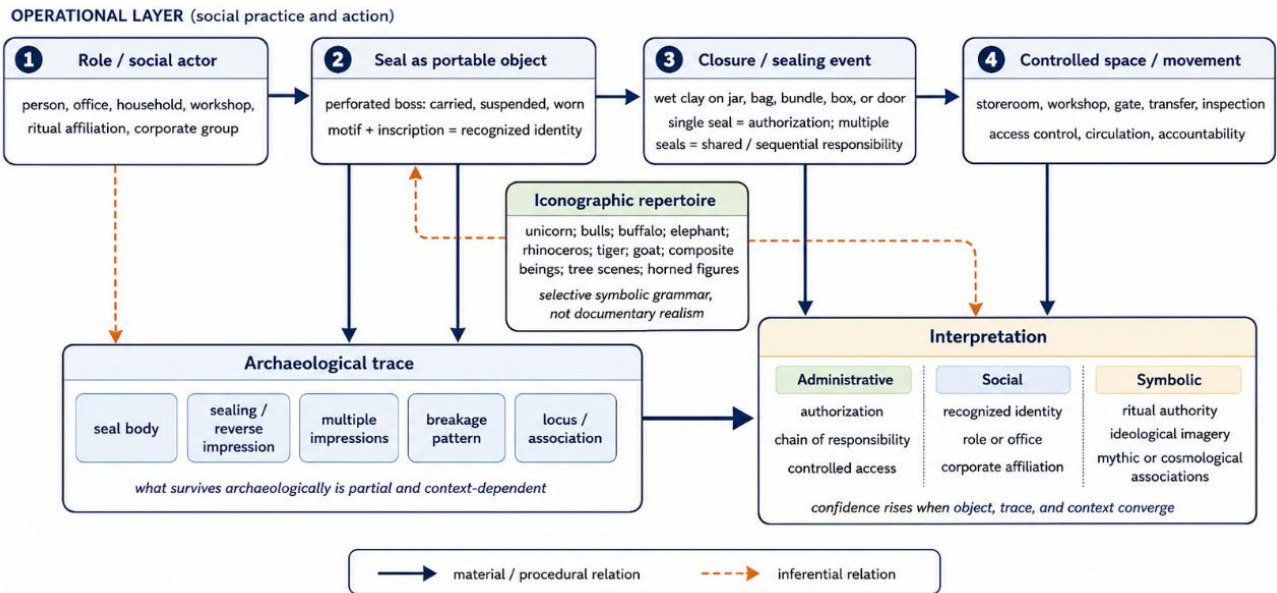
The social function of seals is most evident in their portability. The perforated boss allowed many seals to be carried, suspended, worn, or kept readily accessible. This feature has often been read as evidence that seals belonged to individuals. That is possible, but the category of private ownership is too narrow. A seal may have identified a person, role, office, household, workshop, ritual affiliation, corporate group, or institutional unit.

Repeated combinations of motif and inscription suggest differentiated identities. A seal was not a generic stamp; it carried a particular sign-image combination. Such specificity matters only if the combination was recognized by others. Recognition could operate in an administrative setting, a trading network, a workshop hierarchy, a lineage system, or a ritual community. The seal created social visibility by turning status or authorization into a durable and repeatable material form.

Multiple impressions on a single sealing are especially important because they suggest shared or sequential responsibility. A single impression might be interpreted as one authorizing agent. Several impressions can imply inspection, transfer, co-authorization, or staged accountability. This procedural pattern is stronger than a simple merchant-brand model because a brand marks property, whereas a multi-seal sealing can record a chain of responsibility.

Iconography should be handled with similar caution. The common animal-in-profile format, inscription band, and repeated object before the animal show a conventional visual grammar. The unicorn motif is prominent, but bulls, buffalo, elephants, rhinoceroses, tigers, goats, composite creatures, tree scenes, and horned figures complicate the repertoire. The visual system is selective rather than documentary: it presents socially meaningful forms rather than ordinary life [9].

Religious or ideological interpretations are strongest for seals with complex scenes: horned figures, tree scenes, kneeling figures, composite beings, or human-animal interactions. These images should not be reduced to commodity marks. They may encode mythic narratives, ritual practices, cosmological categories, or symbolic authority. Yet they should not be generalized to the entire seal corpus. In many administrative systems, symbolic authority and practical control work together; the Indus material may reflect such overlap.



Seals mediate between role and controlled action; archaeological traces preserve only part of this documentary ecology, so interpretation must integrate portability, sealing procedure, context, and iconography.

**Figure 6. Documentary ecology of Indus seal use. Source: authorial conceptual model; it clarifies the relationship among role, object, closure, controlled space, archaeological trace, and interpretation.**

### 8. Inscriptions and the Limits of Decipherment-Based Argument

The Indus script remains undeciphered. The absence of a bilingual text, the brevity of inscriptions, the limited number of long sequences, and uncertainty about the underlying language or languages make traditional decipherment claims fragile. This article therefore does not rely on reading signs as specific names, offices, commodities, taxes, or divine titles.

What can be studied securely is structure. Statistical analyses have shown that sign sequences are not random. They display positional tendencies, repeated beginnings and endings, and correlations among signs. Markov, n-gram, and network studies identify ordering constraints without assuming meanings [15]-[17]. Such work does not decipher the script, but it demonstrates that inscriptions were conventionalized rather than arbitrary decoration.

This structural conclusion matters for function. Short inscriptions could have served as institutional labels, classifications, authorizations, coded identifiers, or other formal marks. Their message may have been linguistic, logographic, semasiographic, numerical, emblematic, or mixed. The functional point is that the signs were formalized and repeatable. They likely mattered in procedures of recognition and control even if their exact semantic content remains unknown.

Recent semantic models linking signs to taxation, trade, craft licensing, commodity control, and access control are valuable because they integrate archaeology with sign-internal analysis. However, they remain hypotheses until independently testable. The archaeological pattern can support the existence of control procedures without proving that a particular sign means tax, craft, commodity, gate, or office [13], [14]. A journal-ready argument must retain this distinction.

Digital sign recognition and allograph studies can improve the reliability of sign identification, especially where sign lists have been inflated by inconsistent drawing, photography, or classification. Yet computational methods must be tied to archaeological metadata. Recognizing a sign is not the same as understanding its social function; the latter requires site, context, object class, image, wear, and associated artifacts [18].

### 9. Regional Diversity and Interregional Exchange

Older interpretations often treated the Indus seal system as homogeneous. More recent work emphasizes regional diversity in motif frequency, carving style, assemblage composition, and contextual association. The Greater Indus region covered a large and ecologically varied zone, and similar object forms may have participated in different local procedures. A seal from Mohenjo-daro, Harappa, Dholavira, Lothal, Kalibangan, Chanhudaro, Banawali, or Bagasra should not automatically be assigned the same institutional context [6], [9].

The question of centralization is therefore complex. Standardized seal forms, weights, signs, and motifs imply shared norms, while regional variation and the absence of long royal inscriptions suggest that authority may not have followed a Mesopotamian royal-bureaucratic model. Seals may have helped maintain shared standards across a corporate or

heterarchical urban network. They could allow different communities to participate in recognizable procedures without being governed by identical institutions.

#### 9.1. Adoption, adaptation, and selective rejection

Older interpretations often treated the Indus seal system as a relatively homogeneous institutional technology. This view is now difficult to sustain. Recent studies emphasize regional variation in motif frequency, carving style, assemblage composition, and archaeological association. The Greater Indus region covered a wide and ecologically diverse zone, and similar-looking objects may have operated within different local procedures. A seal from Mohenjodaro, Harappa, Dholavira, Lothal, Kalibangan, Chanhudaro, Banawali, or Bagasra should therefore not be assigned automatically to the same institutional setting [6], [9].

The problem is not whether the Indus world was standardized or diverse. It was both.

Standardized seal forms, weights, signs, and motifs point to shared norms across a large interaction sphere. At the same time, regional variation and the absence of long royal inscriptions caution against assuming a Mesopotamian-style royal bureaucracy. Seals may have helped sustain common procedures across a corporate or heterarchical urban network, allowing different communities to participate in recognizable practices without being governed by identical institutions.

#### 9.1. Adoption, Adaptation, and Selective Rejection

Interregional evidence adds another layer of complexity. Indus and Indus-related seals appear in the Gulf and Mesopotamian worlds, but their presence does not mean that Indus institutions were simply exported abroad. The Gulf-type seal tradition is especially important because it shows adaptation rather than direct replication. A seal could move with a trader, migrant, package, intermediary, or local institution that adopted Indus-derived imagery. External finds are therefore historically significant, even when few in number, but they should not be read as proof that Indus administrative procedures were reproduced unchanged outside South Asia [20].

Three outcomes need to be distinguished: adoption, adaptation, and selective rejection.

Adoption refers to the use of Indus-style seals, motifs, or inscriptions in contexts where the object continued to signal Indus affiliation. Adaptation refers to hybrid objects, especially Gulf-type seals, that incorporated Indus-derived features while serving local mercantile or administrative practices. Selective rejection, or non-adoption, refers to situations in which contact with the Indus world did not produce the wholesale adoption of Indus seal formats. Local institutions may already have possessed effective media for authorization, accounting, or identity. These outcomes were not mutually exclusive and could coexist within the same exchange zone.

The concept of translation is useful here. Objects crossing cultural and institutional frontiers often translate authority from one material language into another. An Indus motif on a Gulf-type seal could signal connection to Indus networks while also becoming legible within Dilmun or Gulf administrative practice. Conversely, Indus users may have encountered foreign sealing technologies without adopting their full bureaucratic logic. What travels, in such cases, is rarely an entire institution. More often, it is a selected protocol: a material form, a way of impressing clay, a visual claim to identity, or a procedure for making responsibility visible.

Future comparative work should therefore ask which layers of sealing practice moved and which did not. These layers include material, shape, inscription, motif, closure medium, place of use, and associated accounting devices. Such an approach prevents interregional finds from being overinterpreted either as evidence of direct colonial administration or as merely symbolic exchange. It also turns regional variation into evidence, rather than treating it as noise to be smoothed away.

### 10. Digital, Archaeometric, and Experimental Research Agenda

The next major advance in Indus seal studies is unlikely to come from another unsupported decipherment. It is more likely to come from better data architecture, imaging, experimental archaeology, use-wear analysis, and contextual integration. The field needs open relational databases that link object ID, site, phase, locus, material, dimensions, inscription, motif, image, 3D scan, find context, associated artifacts, publication, museum number, and confidence level. Without this infrastructure, claims about distribution, typology, or function remain difficult to test and hard to reproduce.

Three-dimensional imaging and reflectance transformation imaging should become standard for both seals and sealings. Flat photographs often obscure microtopography, abrasion, reworking, tool marks, and impression depth. Applied at scale, microtopographic methods could test whether particular motifs were produced by specific workshops, whether regional centers shared carving traditions, and whether seal manufacture changed over time [10].

Experimental sealing is equally important. Replicated seals and sealings should be tested on cords, woven mats, cloth bags, ceramic jar stoppers, wooden doors, boxes, and reed packages under controlled conditions. The resulting impressions could then be compared with archaeological sealings to infer closure type, pressure, clay moisture,

breakage pattern, and handling. This would move discussion from broad claims about “administration” toward testable procedural hypotheses.

Residue and use-wear studies should also shift attention from seals alone to closure systems. If sealed containers, sediments, or associated residues can be sampled, lipid, protein, starch, phytolith, or microbotanical evidence may help identify broad classes of contents. Such analysis would not decipher inscriptions. It could, however, test whether particular sealing contexts correlate with specific substances, storage practices, or handling environments [21].

Machine learning has a role, but it should be kept in proportion. It can improve grapheme recognition, motif extraction, allograph clustering, and pattern detection across large image sets. Yet models trained on biased photographs or inconsistent labels will reproduce those biases. Computational outputs must therefore be tied to archaeological questions: Do sign variants correlate with site, phase, material, or motif? Do motifs cluster with closure types? Are similar inscriptions distributed across distant settlements? The goal is not automated interpretation, but reproducible, metadata-rich analysis.

### **11. Discussion: Toward an Evidence-Weighted Multifunctional Model**

The evidence supports a multifunctional model, but not an undifferentiated one. To say that seals had many functions is not enough if every object is allowed to perform every role. A stronger model assigns function by object class, context, and evidentiary strength.

Sealings with closure impressions provide direct evidence for sealing and access control. Seals with bosses indicate portability and possible identity display. Seals from gates, storerooms, workshops, or weight-associated contexts support administrative and economic interpretations. Narrative motifs support symbolic or ritual readings for specific subsets. Short formulaic inscriptions show conventionalized marking, but they do not yet provide secure semantic readings.

The strongest supported function is administrative closure control. This does not necessarily imply a centralized state bureaucracy. It means that certain goods, rooms, containers, or packages were closed in ways that required recognized seal impressions. Such procedures imply accountability, restricted access, and the possibility of later verification. A seal impression made a closure socially visible by showing that an authorized person, role, or institution had intervened. A second major function is economic regulation. This includes measurement, storage, transfer, craft control, and possibly taxation, licensing, or rationing. The evidence is strongest when economic claims rest on sealings, weights, storage installations, gates, workshops, and repeated marks. It is weaker when it depends on reading specific signs as commodity names or fiscal terms. A cautious formulation is therefore preferable: seals helped regulate economic procedures, but the precise economic content of individual inscriptions cannot yet be securely read.

The third function concerns social identity and institutional authority. The seal body, material, boss, image, and inscription created a portable sign of recognized status. This status may have belonged to an individual, but it may also have belonged to an office, workshop, household, corporate group, or institutional role. The present evidence favors a mixed model: seals were personally handled, but institutionally meaningful.

The fourth function is symbolic and ritual authorization.

This function is strongest for a subset of seals with complex iconography. It should not be generalized to the entire corpus, but neither should it be dismissed as secondary decoration. In many administrative systems, symbols of animal, divine, ancestral, or cosmological authority legitimate practical control. The Indus animal repertoire may have worked in this way, giving material procedures a recognized symbolic force.

This model also clarifies why direct comparison with Mesopotamia must be limited. Mesopotamian sealing systems are documented by long texts and better-known institutions; Indus systems are known through objects, contexts, short inscriptions, and visual conventions. The Indus world may have had sophisticated procedures without adopting the same textual habits. The absence of long royal inscriptions does not imply administrative simplicity. It indicates a different balance among material standardization, short signs, visual authority, and procedural control [19], [25].

### **12. Limitations**

This study is based on published material, not new excavation or first-hand reclassification of the entire corpus. It cannot resolve uncertain provenances or unpublished contexts. Counts used in visualizations derive from different publication histories and object definitions, and should not be treated as statistically complete or directly additive.

The undeciphered script sets a hard limit on semantic interpretation. The study can argue for formalized marking, institutional use, and compatibility with economic control, but it cannot identify specific names, commodities, taxes, offices, or divine titles. Functional categories also overlap. A seal could be administrative, economic, social, and symbolic at the same time. The analytical separation used here is a heuristic rather than a claim about how ancient users categorized these objects.

Finally, preservation bias affects sealings, organic closures, containers, and spatial associations. Absence of evidence cannot be converted into evidence of absence. The model is strongest where direct sealing evidence, contextual

association, object design, and material standardization converge. It is weakest where interpretation depends on unverified semantic readings or broad generalization from famous examples.

### 13. Conclusion

Indus seals should be understood as institutional media embedded in a broader documentary ecology. They were not merely miniature artworks, although their artistry mattered. They were not merely merchant brands, although they likely participated in regulated exchange. They were not merely religious amulets, although some carried powerful symbolic imagery. They were not simply texts waiting to be deciphered, although their inscriptions formed a structured sign system. Their significance lies in how these dimensions interacted through procedure.

The strongest archaeological evidence comes from sealings and closure contexts. These show that seals could authenticate, restrict, and monitor access to goods, containers, rooms, packages, and storage systems. Economic interpretations are strongest when tied to weights, gates, workshops, storage, and exchange contexts. Social interpretations are supported by portability, bosses, repeated sign-image combinations, and possible shared authorization. Ritual and ideological interpretations are strongest for selected motifs and probably contributed to the authority of the object. Script studies show formal structure but cannot yet supply secure readings.

The broader significance is that Indus seals help explain how one of the ancient world's largest urban traditions could sustain coordination without the textual and royal display familiar from Mesopotamia and Egypt. They point to a form of governance in which authority was material, procedural, and distributed: embedded in standardized artifacts, repeated visual conventions, controlled spaces, and recognized acts of closure. This does not make the Indus Civilization administratively simple. It reveals a different documentary logic, one in which short signs, portable tools, and sealed clay could make responsibility visible across households, workshops, cities, and exchange zones.

The best current model is therefore an evidence-weighted multifunctional model. Indus seals functioned as portable authorization devices, administrative tools, social identifiers, and symbolic media. Future work should link objects to contexts through open databases, high-resolution imaging, experimental sealing, use-wear study, residue analysis of sealed containers, and integrated analysis of seals with weights, gates, storerooms, workshops, and tablets. This approach will not automatically decipher the script, but it can make interpretation of the seals more testable, contextual, and internationally publishable.

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